

A MIXED-METHODS INVESTIGATION OF  
PUMPING HUMAN MILK AND FEEDING PUMPED MILK TO INFANTS

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Most U.S. mothers who feed their human milk (HM) to their infants now use pumps and bottles or cups to replace some or all feeding at the breast (FAB). Little is known about how mothers perceive or feel about these practices or how human milk expression (HME) may relate to long-term practices for feeding HM from breasts or bottles.

Longitudinal qualitative data came from 20 mothers in upstate New York who pumped HM and whose infants were fed pumped HM. We interviewed women from pregnancy up to 1 year postpartum, and identified themes with content analysis of transcripts. Longitudinal quantitative data came from the 1,044 mothers in the Infant Feeding Practices Study II who fed and pumped HM 1.5-4.5 months postpartum. We used survival analyses to examine associations between mothers' HME frequency 1.5-4.5 months and the duration of any or exclusive HM and of FAB.

In our qualitative sample, mothers appreciated that pumps and bottles let them share the bonding and burden of feeding infants. However, they found that HME and related tasks were unpleasant or time-consuming and that considerations for HME and bottle-feeding were reduced or absent while FAB. Mothers used data from HME and bottle-feeding sessions to understand their ability to meet their infants' needs. In our quantitative sample, mothers who pumped more often than the median had a significantly higher average hazard for stopping feeding any HM and for feeding HM exclusively, by 40% and 28% respectively, than those who pumped least often. Their hazard of stopping FAB changed over time, but remained significant until 6 months, when

hazards were 6.4 times higher.

For health professionals, these findings provide important insights into mothers' experiences pumping HM and having other caregivers feed it to their infants. Our data also suggest that high-frequency pumping may adversely affect the duration of HM feeding. These findings signal to policymakers that efforts to meet national goals for HM-feeding should include support for FAB and for HME at work. Finally, these findings are a call for researchers to investigate links between pumping and bottle-feeding HM and outcomes for infants and mothers.

## BIOGRAPHICAL SKETCH

Julia Felice earned her B.S. in Biology from the Massachusetts Institute of Technology in 2005. She spent three years afterward teaching public high school math and science in Lexington, Virginia. This experience fueled her drive to address socio-economic and socio-demographic disparities in public health. This drive, in turn, brought Julia to the Nutritional Sciences graduate program at Cornell University.

This dissertation is dedicated to mothers of all kinds in all places.

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## LIST OF ABBREVIATIONS

HM.....	Human Milk
HME.....	Human Milk Expression, or pumping
FAB.....	Feeding At the Breast
IFPS II.....	Infant Feeding Practices Study II

## PREFACE

Infant feeding practices in America are in the midst of their second major shift. In the early 20<sup>th</sup> century, most U.S. infants were fed directly at the breast. By mid-20<sup>th</sup>-century, mothers rapidly and widely adopted formula-feeding (1, 2), a shift that had dramatic adverse consequences for the health of both mothers and infants (3-9). Now, with pervasiveness and rapid speed, U.S. mothers have adopted the use of pumps and bottles to feed their infants their human milk. This shift may have profound implications for the health and well-being of mothers, infants, families, and the nation. It is this phenomenon that led to the mixed-methods doctoral work presented here.

As consistent evidence of the adverse consequences of formula-feeding emerged, so did national recommendations to feed human milk exclusively until six months and continued through a year or beyond (10). American women responded in kind with an encouraging and consistent rise in human milk-feeding since a nadir in 1971 (1, 2). However, in the face of powerful constraints to feeding at the breast—namely, mothers working outside the home (11-16)—this rise has been gradual. Mothers' increasing desire to feed human milk, as evidenced by the 75% who begin doing so (17), has conflicted with their need or desire to work in spite of the continued absence of adequate maternity leave.

The recent stark shift to pumping and bottle-feeding human milk was catalyzed by a purported solution to this conflict: the advent of high-efficiency, commercially-available double-electric breast pumps (18). Women have been expressing milk from their breasts for hundreds of years, either by hand or with devices (19-23). These new high-efficiency pumps, however, provided mothers with a way to avoid or reduce formula use when feeding at the breast is regularly unavailable. In rapidly increasing numbers, women have done just that: most mothers

who feed human milk now pump and bottle-feed their milk in place of some or all feeding at the breast. The consequence of this shift is that, while maternal practices for providing human milk and infants' experiences being fed human milk have entered into uncharted territory, research and recommendations lag far behind. All but some recent research has classified and prescribed infant feeding practices by content—human milk *vs.* infant formula—without considering feeding method. This distinction was unimportant when most human milk-feeding was at the breast. However, the incorporation of pumps and bottles into practices for human milk-feeding lead to three distinct behaviors: direct breastfeeding, the removal of milk from breasts with pumps, and the feeding of that milk to infants with bottles. Thus, the widespread use of pumps and bottles has fundamentally changed how we can describe and study dyads and their outcomes (**Figure 1**). Infants may now be described by the proportion of human milk they are fed, regardless of whether it is fed by breast, bottle, or both, and by the proportion of their feedings that come from bottles. Mothers may now be described by how often they remove milk from their breasts with direct breastfeeding and by how often they do so by pumping. Each of these practices and their impacts must be studied, yet the scientific literature does not yet reflect this distinction.

Further, despite the lack of data, national recommendations (10) treat and endorse pumping and bottle-feeding human milk as equivalent to feeding at the breast for maternal and infant outcomes. The Affordable Care Act (24) promotes and protects pumping by mandating coverage of breast pumps and time and space for mothers to pump at work. This divergence between evidence and policy is staggering in the scope of its potential impact, given the high prevalence of pumping and bottle-feeding human milk, and in the number of questions and concerns that are currently unanswered.

It is unknown how much of the risks associated with bottle-feeding formulas are due to the method of feeding—i.e. bottle vs. breast—rather than what is fed. Early qualitative work and recent epidemiologic and experimental data indicate that bottle-feeding human milk may modify the health, growth, and developmental benefits conferred to infants by feeding at the breast and may introduce other risks. No data yet compare methods of removing milk from breasts—i.e. pumping vs. feeding at the breast—for maternal health outcomes.

While work-related obstacles to feeding at the breast will presumably remain, the practices of pumping and bottle-feeding human milk will likely continue to increase. Thus, it is urgent that health professionals, researchers, and policymakers understand how and why mothers pump their milk, how and why they and other caregivers prepare and bottle-feed that milk, and what potential consequences these practices might have for long-term infant feeding outcomes and consequent health outcomes for the dyad.

### ***“Breastfeeding” as we Currently Measure, Understand, Prescribe, and Practice It***

National and global recommendations are based on a large body of evidence that clearly establishes human milk as the normative infant food against which alternative foods should be evaluated. It is for this reason that we continue to measure national human milk-feeding practices and that mothers’ intentions and practices for human milk-feeding continue to rise.

Feeding human milk benefits individuals, families, and the public by minimizing health-related financial expenses and creating a healthier and, thus, presumably more productive population. Even in industrialized contexts such as the U.S., human milk-feeding saves and improves the quality of lives. Investigators recently calculated that if 90% of infants were fed only human milk for 6 months, 911 deaths would be prevented nationally (25). Other

investigators found that, in comparison to 1,000 infants exclusively breastfed for 3 months, 1,000 never-breastfed infants required 2,033 more office visits, 212 more days in the hospital, and 609 more prescriptions in the first year of life (26).

A major limitation of the literature is that, because of ethical and practical considerations in randomizing human milk- or formula-feeding, most data are observational. However, one large-scale experimental trial was conducted in a developed country setting: the Promotion of Human milk-feeding Intervention Trial (PROBIT) in Belarus, in which hospitals were randomized to promotion of human milk-feeding or standard care (3). Thus, the intervention effect compared infants born in hospitals that promoted human milk-feeding to those born in baseline hospitals. Despite loss of statistical power because of higher than expected human milk-feeding rates and low illness rates in both trial arms, there were clear between-group differences in gastrointestinal infections (4) and cognitive development (27). Protective effects would likely be stronger in the U.S., where human milk-feeding rates are lower (17) and infection rates higher than in Belarus (25, 28).

A large body of observational data has been the subject of many meta-analyses and systematic reviews; these data consistently link suboptimal human milk-feeding with higher risks to infants. These risks include serious respiratory infections (8, 29), otitis media (6), Sudden Infant Death Syndrome (9), acute lymphoblastic leukemia (6), and obesity (30-32). Meta-analyses also show that human milk-feeding among infants with a family history leads to a reduced risk of allergic rhinitis (33), atopic allergies (34), and asthma (6) in the child. Suboptimal human milk-feeding has been linked with increased risk of type 2 diabetes mellitus and diminished insulin sensitivity later in life (35). Early evidence also suggests an association with risk for type 1 diabetes (6) and high blood pressure (36) later in life.



Associations between suboptimal human milk-feeding and maternal health outcomes have not been studied as extensively as associations with infant health outcomes, but available evidence persuasively supports human milk-feeding to reduce risks to maternal health. In meta-analyses, increases in mothers' lifetime human milk-feeding practices have been linked to lower risks of breast cancer (37) and ovarian cancer (6). Observational evidence suggests associations with other maternal health outcomes that are supported by plausible biological mechanisms. Health outcomes in mothers that are optimized by human milk-feeding include natural contraception (38), promotion of postpartum weight loss (39, 40), and improvements in insulin sensitivity, blood cholesterol and triglycerides (41) during lactation. Some evidence suggests these effects may be long-lasting, as human milk-feeding has also been linked to long-term lower risks of maternal type 2 diabetes (41, 42), hypertension, hyperlipidemia, and cardiovascular disease (43, 44).

This body of evidence informs recommendations from the American Association for Pediatrics to feed only human milk for 6 months followed by gradual introduction to solids and continued human milk-feeding through 1 y or beyond (10). The public health importance of human milk-feeding spurred the Surgeon General's recent call to action (45).

Consequently, the duration of any and exclusive human milk-feeding have consistently risen in the U.S. since a nadir in 1971 (46). From 1971-2001, breast feeding (BF) initiation increased from 24.7% to 69.5%, and BF at 6 mo from 5.4% to 32.5% (1, 2). Between 1996-2001, the rise in human milk-feeding at 6 mo was greater than the rise in human milk-feeding initiation, indicating that more women are starting to feed human milk and continuing to do so for longer (2). This trend continues into the new century. Between 1999-2007, human milk-feeding initiation rose from 68.3% to 75% and human milk-feeding at 6 mo rose from 32.6% to

43% (46). However, this rise has been gradual, and outcomes remain far short of recommendations, Healthy People 2020 goals (47), and practices in other developed countries (48). By 6 mo postpartum, only 49% are feeding any human milk, and only 16.4% are exclusively feeding human milk as recommended (17).

A large literature shows that human milk-feeding is predicted by many demographic, biologic, attitudinal, social, and contextual factors. Higher education, income, and age are consistently associated with longer human milk-feeding duration (13, 49, 50). Black women are less likely to feed human milk than Hispanic and non-Hispanic white women (13). Eligibility for or participation in the Federal Supplemental Program for Women, Infants, and Children (WIC) is associated with shorter human milk-feeding duration (51). Recent evidence has linked maternal obesity at conception with poorer human milk-feeding outcomes (52-54), a phenomenon with anatomic, medical, sociocultural, and psychological predictors (54).

One of the most important predictors of human milk-feeding is maternal employment outside the home. Employment is a key hindrance to national human milk-feeding goals (11-16) and a key cause for the rise of pumping and bottle-feeding human milk (55, 56). From 1975-2004, the proportion of American women with children < 3 y old in the work force increased from 34 to 60.7% (57). Alone among developed countries, the U.S. does not mandate paid maternity leave (58). This means that mothers balance the demands of human milk-feeding and work, a challenge made worse if the return to work begins soon after birth or with high intensity (16, 59). Although it is encouraging that some of the largest gains in prevalence of any human milk-feeding have been seen among women employed full-time, human milk-feeding initiation and duration still lag behind women who do not work (11). In a recent longitudinal survey cohort, human milk feeds declined 6.6% in the first month after return to work, but declined

20.9% among mothers unable to pump or feed at the breast during the work day (56). Among mothers of infants weaned at 1-2 mo, 22.4% cited the inability to comfortably pump or feed at the breast at work as an important reason for human milk-feeding cessation (60). Moreover, mothers who maintained human milk-feeding after return to work were older, had higher income and education, and were more likely to be white and married (56). Thus, lower-income women and those employed part-time may be more subject to work-related constraints, as their jobs are less likely to provide paid leave or job protection.

### ***Obstacles and Avenues: The Use of Pumps and Bottles to Feed Human milk***

Given these barriers to optimal human milk-feeding, it is not surprising that mothers have seized the opportunity provided by high-efficiency pumps to feed their human milk when feeding at the breast is either unavailable or undesired. The only national data available on pumping come from a recent longitudinal national survey cohort, the Infant Feeding Practices II (IFPS II) (61). In the IFPS II, mothers were surveyed prenatally and 10 times across the first year. Three of these surveys included modules on practices and equipment for pumping human milk.

In the IFPS II, among human milk-feeding mothers of infants in the 1.5-4.5 mo age group, 85% had successfully pumped their milk at some point, a quarter did so regularly, and more than half had started pumping before 1 wk postpartum (55). Nearly half of mothers feeding human milk between 6.5-8.5 mo pumped occasionally or regularly, and 6% never fed human milk directly at the breast. The participants used a variety of pumps, but those who used electric pumps were more likely to pump regularly across the year. Because the IFPS II participants as a whole were more likely to be white and married and had higher education and income levels than

a nationally representative sample, and given these factors are known to associate with feeding at the breast, the pumping rates in the general population may not be as high as the estimates from IFPS II. However, the direction and magnitude of the trend in this group suggests a similarly concerning national trend.

A range of socio-demographic factors predicted pumping practices among IFPS II mothers. Many of the known predictors of human milk-feeding also predict pumping practices in the IFPS II. Human milk-feeding mothers of infants 1.5-4.5 mo old were more likely to pump, and to pump regularly vs. occasionally, if they were college-educated or had an income >350% of the national poverty level (55). However, many factors show a different relation with pumping compared to with feeding at the breast. Although mothers without prior human milk-feeding experience (62) and those who are embarrassed to feed at the breast in public (63-65) are less likely to feed their infants at the breast, they were more likely to pump at all and regularly compared to multiparous women and those not embarrassed to breastfeed in public (55). Moreover, although mothers' long-term intentions for human milk-feeding positively predict their feeding at the breast practices, women in the IFPS II with the longest intentions for any and exclusive human milk-feeding were less likely to pump.

Although obesity is negatively associated with the likelihood and duration of human milk-feeding (52-54), prevalence of ever pumping in the first year was ~80% across BMI categories, and ~90% of women who attempted pumping in each category did so successfully (66). However, obese women were more likely to attempt pumping before 2 mo, and were less likely to do so successfully, compared to overweight and normal weight women. This may be explained, in part, by anatomical, physiological, and psychosocial factors (52, 53) that hinder feeding at the breast for obese women. Higher risk of cesarean or medicated delivery among

obese women (67, 68) may also partly explain this trend, as these factors also predicted any and regular pumping between 1.5-4.5 mo (55).

IFPS II mothers who reported working in the previous month were more likely to pump regularly across the first year than mothers not working (55). Mothers most commonly cited a need to provide human milk for another caregiver to feed as a reason for pumping across the year. Mothers cited a range of other reasons for pumping from a closed list, including building an emergency stock, relieving engorgement, increasing mothers' supply, and compensating for when she doesn't want to or her infant cannot feed at the breast.

### ***Why the surge in pumping and bottle-feeding human milk raises concerns***

The use of pumps and bottles fundamentally changes the nature of feeding human milk. Formerly, feeding human milk was primarily only a dyadic behavior, in which human milk was removed from breasts and fed to infants simultaneously. This change has profound implications for how we understand and recommend infant feeding practices (**Figure 1**). Further, this change may impact health outcomes for mothers and infants, and existing national recommendations are based on evidence that does not yet account for this change.

Feeding at the breast differs from feeding from a bottle in two key ways. An infant fed at the breast begins with non-nutritive suckling, where the infant sucks rapidly and vigorously as the start of human milk flow is delayed and then more slowly as flow begins (69). The human milk then follows a “gradient,” higher in protein and carbohydrate at the start and higher in fat at the end of a feed (70). Formula-fed infants, in contrast, receive an effortless and immediate flow of milk that has a constant composition. Thus, in comparison to infants fed at the breast, formula-fed infants expend less energy to eat and lack a perceptible, high-fat “end-of-feed”

signal. This may explain, in part, why formula-fed infants consume greater volume and energy in a feeding (71).

Styles for feeding human milk may differ between the breast and the bottle. It has been argued that feeding method alters the balance of control over feeding. Meal size, interruption, and termination within a bottle feed are under greater control by the caregiver. In contrast, breast-fed infants are more able to determine size and interval of feeds themselves (72). In a prospective cohort, formula-feeding mothers restricted their infants' food intake more often than human milk-feeding mothers at 1 year (73).

In the Infant Feeding Practices Study II (IFPS II), infants who were bottle-fed—regardless of whether the bottle content was human milk or formula—in early infancy showed more bottle-emptying (74) and more rapid weight gain (75)(76) later in infancy than infants only fed at the breast. It is unknown whether these findings reflect infants consuming more human milk volume and energy from bottles than from breasts, differences in feeding styles between feeding human milk from bottles *vs.* at the breast, or both. Thus, practices for bottle-feeding pumped human milk must be characterized. An unanswered question is whether the use of breast pumps and bottles to feed human milk impacts mothers' perception of their infants' needs and the capacity of mothers' supply to meet them, and how these perceptions may impact feeding practices.

Pumped human milk fed from a bottle may differ from human milk obtained directly from the breast. Although feeding at the breast reduces the risk of illness, infection, and suboptimal growth compared to formula feeding, it is unknown whether the same benefits are conferred when pumped human milk is fed from a bottle.

Pumped human milk fed from a bottle may differ in macronutrient content compared to

human milk fed at the breast. Recent experimental evidence shows that the energy and fat content of pumped human milk is highly variable and sometimes lower than accepted values for mature milk (77, 78). This evidence raises concerns for infants fed pumped human milk, as nutritionally inappropriate milk may hinder optimal growth and weight gain. As the composition of human milk changes across the year to meet infant needs, these concerns are magnified for infants who are fed human milk that was pumped weeks or months earlier.

Moreover, the addition of pumping, storage, and preparation to infant feeding provides cumulative opportunities for contamination. In a cross-sectional sample, investigators (79) found significantly more bacterial contamination among samples mothers pumped at home versus at a healthcare facility. This raises concerns for infants fed human milk that was pumped when mothers were at work. Three quarters of human milk samples purchased via the Internet had high overall bacterial growth, including *Staphylococcus* bacteria (80).

The microbial and macro- and micronutrient integrity of pumped human milk must be investigated further, and associations with infant health outcomes examined, particularly among preterm, medically compromised, or high-risk infants. A critical first step to these investigations is characterizing in detail mothers' practices for pumping and storing milk, and mothers' and other caregivers' practices for preparing and feeding it.

Mothers who pump and bottle-feed their human milk may have different long-term human milk-feeding practices than those who only feed their infants at the breast. Pumping and bottle-feeding human milk, when substituted for feeding at the breast, may adversely affect long-term feeding outcomes, including the introduction of formula and solids. These potential effects may relate to mothers' perceptions of their infants' needs and of their own milk supply, which are important determinants of mothers' feeding practices (60, 62, 63, 81). Potential effects of

pumping and bottle-feeding human milk on long-term feeding practices may also result from mothers' attitudes toward and experiences with pumping.

First, mothers who pump and bottle-feed their milk may have different perceptions of their milk supply than mothers who only feed their infants at the breast. Mothers commonly cite a perception of low milk supply as a reason for stopping any or exclusive human milk-feeding in ethnographic (82) and epidemiologic (62, 63) studies, including the IFPS II (60). However, while up to half of women believe their supply to be insufficient, only a small percentage suffer from a physiological impairment to lactation (13, 50).

Second, mothers who bottle-feed their milk may have different perceptions of their infants' needs than mothers who only feed their infants at the breast. Recent work by Huh and colleagues associated early introduction of solids with an increase in risk for obesity at 3 years among formula-fed but not human milk-fed infants (83). The authors hypothesized that mothers who feed human milk may be more able to recognize and respond to infant satiety cues.

However, the authors did not distinguish human milk fed from breasts *vs.* from bottles. In the IFPS II, infants that were bottle-fed more intensely early in infancy—whether human milk or formula—showed more rapid weight gain by the end of the first year than those fed at the breast (76). Thus, some increased obesity risk may be conferred by bottle-feeding *per se* compared to feeding at the breast.

Third, mothers' long-term intentions and practices for infant feeding may be affected by their attitudes toward and experiences with pumping. Mothers' attitudes toward human milk-feeding impact their human milk-feeding intentions and behaviors (84). For example, in addition to perceived low milk supply, mothers also commonly cite pain and body ownership as reasons for human milk-feeding cessation (60). These attitudes and perceptions could plausibly arise



with pumping, and may explain, in part, why pumping was shown to increase the duration of any human milk-feeding for some women, but not others (56, 85).

Thus, it must be known whether pumping and bottle-feeding human milk relate to mothers' perceptions of their infants' needs in ways that differ from ways that feeding at the breast informs those perceptions. In turn, it must be known if any effect of pumping and bottle-feeding human milk on mothers' perceptions of their infants' needs and their ability to meet them then have an effect on later feeding practices. Mothers' attitudes toward pumping, and their potential impact on long-term feeding practices, must be characterized.

Pumping likely affects mothers' attitudes toward and experiences with employment. Pumping may provide a means to cope with the often opposing goals of working and maintaining feeding at the breast. However, evidence from the IFPS II indicates that pumping is an inferior substitute for feeding at the breast for maintaining long-term human milk-feeding. Women unable to feed at the breast at work, whether or not they pumped, fed human milk for shorter duration than those who were able to feed at the breast at work (56). Inasmuch as IFPS II mothers were older and higher income on average, employment may have a still more detrimental effect among mothers who are younger or of low socio-economic status and who may have worse workplace support for pumping or human milk-feeding.

Moreover, mothers' success at pumping at work and, thus, human milk-feeding, may vary widely depending on a range of workplace factors beyond duration of maternity leave. The Affordable Care Act (24) promotes workplace pumping by mandating provision of "reasonable" time to pump and non-bathroom space that is shielded from view to do so. However, it is unknown how mothers practice and experience pumping at work, and how the space and time available to do so relate to their intentions and practices for pumping and feeding their milk.

Moreover, women that work for employers with less than 50 employees do not benefit from these mandates, and are further vulnerable to potentially inadequate support offered by their employers. Restricting pumping to home is not likely a feasible method of meeting human milk demand, particularly if mothers have other childcare obligations. Both feeding at the breast and pumping at home might increase supply, pain, and engorgement at work. Thus, it must be known how mothers experience pumping at work so that they may be supported in their goals to do so.

### ***A mixed-methods investigation of pumping and bottle-feeding human milk***

To begin the work of addressing these gaps in knowledge, the aims of this doctoral work were twofold. First, we aimed to describe mothers' attitudes, perceptions, and practices for pumping and feeding their human milk, and how they were constrained or facilitated in meeting their goals for pumping and human milk-feeding. Second, we aimed to determine the impact of pumping practices in the early postpartum period on long-term feeding outcomes, such as the duration of any and exclusive human milk-feeding and of feeding at the breast.

The doctoral work described in subsequent chapters is a mixed-methods dissertation project that addresses these aims. The first study is a longitudinal ethnography of twenty socio-demographically diverse mothers across three counties in upstate New York. Mothers described their attitudes, perceptions, and practices for pumping and bottle-feeding their human milk in semistructured interviews and in-home observations from late pregnancy up to a year postpartum. Interview guides were created to elicit anticipated and emerging themes, and were informed by available data on pumping, feeding at the breast, and bottle-feeding. The second study is a secondary analysis of IFPS II data, which provides the only opportunity to quantify practices for pumping and bottle-feeding and to examine their impacts on long-term infant

feeding outcomes.

The structure of the chapters in this dissertation reflects how the use of pumps and bottles has fundamentally changed human milk-feeding. Human milk-feeding has changed from a dyadic behavior to one in which human milk is removed from breasts by a pump and then fed to infants by a bottle reflecting two separate behaviors. As such, findings from this doctoral work are presented in two ways: from the mothers' perspective and from the infants' perspective. Qualitative findings on mothers' attitudes, perceptions, and practices for pumping are presented in Chapters 1 and 3. Epidemiologic findings on the consequences of pumping are presented in Chapter 4. Qualitative findings on feeding pumped human milk are presented in Chapters 2 and 3.

This mixed-method pair of studies has two major strengths. First, the two studies are complementary in design and translational in nature. Data from IFPS II provided key insights for ethnography interview guides—for example, by providing possible reasons for pumping and experiences using pumps. In turn, ethnographic findings provided key insights for IFPS II analyses by suggesting potential mechanisms by which pumping and bottle-feeding practices might be linked to long-term feeding outcomes. For example, ethnography mothers described a longer list of reasons for pumping that demonstrated how those reasons might be analyzed effectively in the IFPS II. Second, although these studies are starkly different in size and design, both include socio-demographically diverse samples of women, studied longitudinally. Human milk-feeding and pumping are not equitably distributed across socio-demographic groups. Thus, diverse groups of women are needed to capture a range of attitudes, perceptions, practices, determinants, and consequences for pumping and bottle-feeding human milk. The longitudinal nature of both studies minimizes reliance on recall. It also allows observation of changes in

attitudes, perceptions, practices, and determinants across the year, changes that are not captured with prior infant feeding.

Together, these complementary studies provide the first in-depth investigation of pumping and feeding pumped milk, without which current infant feeding recommendations are incomplete.

CHAPTER 1

PUMPING HUMAN MILK: A LONGITUDINAL, QUALITATIVE INVESTIGATION OF  
HOW MOTHERS PERCEIVE, FEEL ABOUT, AND PRACTICE HUMAN MILK  
EXPRESSION

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## ***Abstract***

**Background.** Most American mothers who feed human milk (HM) now use HM expression (HME), or pumping, in place of some or all feeding at the breast (FAB). Mothers' perceptions of, attitudes toward, and practices for HME are previously uncharacterized, yet must be understood to investigate their potential implications for maternal health and well-being compared to FAB.

**Methods.** We used longitudinal ethnographic methods among a diverse sample of 20 mothers who used HME, following each from pregnancy through HM-feeding cessation up to 1 year postpartum. Interview transcripts were coded using Atlas.ti.

**Results.** Mothers pumped their HM for reasons that changed over time and reflected their needs and desires, e.g. return to work, latch difficulty, sharing the burden and/or bonding of infant feeding, and maintaining or increasing their HM supply. Mothers reported that pump type and quality were important, yet many perceived that all pumps were less efficient than infants. Many mothers felt HME to be time-consuming, costly, and unpleasant compared to FAB, which was preferred. However, regardless of how often they pumped, most mothers felt HME was necessary to meet HM feeding goals and a welcome means of sharing the tasks and bonding of feeding infants.

**Conclusions.** Mothers' reasons for HME may signal important, modifiable constraints to HM-feeding. The success of HME may depend on access to new, high-quality pumps and support at work. Mothers with difficulty nursing or with unsupportive work environments may be more burdened by the challenges associated with HME. These findings are a call to health professionals to support mothers in their effort to successfully feed at the breast and to pump to the extent that they desire. Further, these findings are also a call to policymakers that they may support HME and, thus, HM-feeding, by providing mothers with affordable, high-quality pumps.

## ***Introduction***

Women have been expressing human milk (HM) from their breasts for hundreds of years with or without the use of devices. However, a new era of infant feeding has emerged: most mothers in the U.S. who feed HM now use breast pumps and bottles to feed HM in place of some or all feeding at the breast (FAB). Human milk expression (HME) is nationally endorsed (10, 86, 87) and legislatively promoted (24), yet recommendations, policies, and campaigns are informed by literature that compares mothers who practice FAB to those who bottle-feed formula.

Research on HME to date is very limited. A recent national longitudinal cohort study, the Infant Feeding Practices Study II (IFPS II), provides early data on HME practices (61). IFPS II surveys measured why and how often mothers pumped at 2, 5, and 7 months postpartum. Most HM-feeding mothers in the IFPS II pumped, some with high intensity or exclusively (56). Other data on HME have compared pump output between HME methods (88-93) or on the impact of a workplace lactation support program on the duration of HME (94). Thus, very little is known about how mothers understand, feel about, or practice HME. This gap has rapidly become a pressing and widespread public health concern, as these understandings, feelings, and practices impact how mothers pump and, thus, feed their HM (19-21).

The psychosocial determinants and consequences of HME must be known, as mothers' perceptions and attitudes toward FAB impact their intentions and practices for FAB (49, 50, 62, 95). Attitudes and perceptions that are often cited as reasons for FAB cessation, such as perceived low HM supply, pain, and body ownership (60, 82), may occur with HME. Mothers with these experiences may reduce or stop HME. This could explain, in part, inconsistent links between HME and longer HM-feeding duration (55, 85, 96). In addition, substituting FAB with

HME may disrupt bonding or emotional benefits that are commonly cited as a reason for FAB (97).

Mothers' employment outside the home is an important predictor of their use of HME (56) because working outside the home hinders FAB (13-16). Our clinical experience has shown that working mothers pump their milk before, during, and after their workdays. It is unknown how mothers pump and store HM at home and at work and what factors may impact their success. This knowledge is important as the authors of a recent review (98) found that HME is only associated with a longer HM-feeding duration for some mothers (55, 85, 96). For working IFPS II mothers, HME was inferior to FAB to maintain HM-feeding (55). Moreover, if HME at work is an inadequate substitute for FAB, this effect may be more important nationally than among IFPS II mothers. IFPS II mothers were older and had higher income than the national average and, thus, may have more support for HME at work (99). Thus, it is essential to characterize how and how much mothers pump and store their HM at home and at work, and factors that may impact their practices.

A critical first step to fill these gaps in knowledge is in-depth qualitative work in a diverse sample of mothers who use HME. Recent longitudinal qualitative data on HME from mothers the U.K. were limited as they were only collected until 6 weeks postpartum, came from the small subsample of HM-feeding mothers who used HME ( $n = 7$ ), and were analyzed *post hoc* (98). Among the few ethnographic investigations of HM-feeding women in the U.S., none has focused on HME, and data have been limited by narrow content, small or homogenous samples, and data from short, recall-reliant, or non-home study designs (82, 100, 101).

We aimed to fill these gaps with ethnographic methods. Because the addition of pumps, bottles, and cups alters the dyadic nature of FAB by separating HM-feeding into two practices—



i.e., removing HM from mothers' breasts and providing it to infants—our results are presented to reflect this separation. We describe our findings and conclusions related to how and why pumped HM is prepared and fed in Chapter 2. Here, we describe mothers' attitudes and perceptions of, strategies for, and experiences with HME, including the reasons that they pumped, how HME was incorporated into mothers' home and work routines and infant feeding choices and practices, and how those attitudes, perceptions, practices, and experiences change over time.

## ***Methods***

We used longitudinal ethnographic methods among HM-feeding women across three counties in upstate New York ( $n = 20$ ). Specifically, we conducted in-depth interviews and observations to explore mothers' attitudes toward, perceptions of, and practices for HME (102-105). Methods are described in further detail in Appendix A.

*Study Participants.* Women  $\geq 21$  years old experiencing healthy pregnancies with singleton infants were recruited from three counties in New York State. Participants were recruited in person and with cards and posters at OB-GYN offices, Supplemental Program in Nutrition for Women, Infants, and Children (WIC) clinics, infant goods stores, and in public, and with emails sent to parenting email lists. Mothers were purposively recruited for heterogeneity on factors associated with HM-feeding, such as marital and employment statuses, age, ethnicity, and parity. Participants gave written consent before the first interview, with separate consent for photo and video recording.

*Longitudinal design.* The first interview was conducted late in mothers' pregnancies, as some may not gather knowledge and develop attitudes, perceptions, and intentions for FAB, HME, and bottle-feeding until the third trimester. The first postpartum interview was conducted

at 2 weeks postpartum to allow time for mothers to establish early FAB patterns while minimizing recall bias and mother fatigue. Subsequent interviews were conducted after important anticipated transitions, such as the start of HME, feeding HM or formula from bottles, or feeding solids, mother's return to work, and any unanticipated, mother-specific transitions such as a major shift in job characteristics that might impact HME. Mothers were contacted every 2-3 weeks for the first 2 months and every 4 weeks thereafter to identify whether transitions had occurred, or at other arranged times due to an anticipated transition. Thus, transitions were nearly always identified within 4 weeks of when they had occurred and, for most mothers, identified within 1-2 weeks. When transitions were identified, interviews were typically scheduled within the following two weeks. Two mothers were difficult to contact in a timely manner because of changes in residence and/or phone numbers. However, both of these participants independently contacted JPF after each of these changes or when they or their infants experienced a transition. Scheduling timely interviews was only problematic with one of these mothers.

*Interviews.* Interviews were semistructured and open-ended, and explored mothers' knowledge and perceptions of, attitudes toward, and intentions and practices for FAB and bottle-feeding pumped HM and formula. Multiple interview guides were created to reflect each anticipated transition. Each guide contained the relevant recurring themes in addition to questions specific to the recent transition. Guides were also malleable to account for between-dyad variation, as mothers and infants experienced transitions separately, concurrently, or not at all. For example, for some mothers, the onset of HME and/or bottle-feeding coincided with the return to work; as such, these interview guides were merged. Other mothers did not return to work, and were not interviewed with the return-to-work guide. Interviews were also malleable to

account for unplanned topics, such as the presence of a new family member that impacted HME and feeding practices. Moreover, because of the Grounded Theory (106, 107) nature of this work, emerging themes were incorporated into subsequent interviews with that mother and other mothers as needed. Some non-mother HM-feeding caregivers were present during interviews, such as baby's father or grandmother. A few of these offered feeding information previously unknown to mothers. Interview guides may be found in Appendix B.

Interviews were audio-recorded, and recordings were transcribed and checked twice. Field notes were expanded, organized, and typed within 24 hours of interviews. Predetermined themes were identified with literature on FAB and formula-feeding, such as themes about responsive feeding practices (72), and emerging literature on HME, such as mothers' reasons for HME (56). Emerging themes were identified as interviews progressed. Themes were examined with content analysis using open- and closed-coding in Atlas.ti (Berlin, Germany). Coding was ongoing and iterative for predetermined themes, guided subsequent interviews with some or all mothers, and identified emerging, unanticipated themes. Coding was shared by four co-authors (JPF, CWQ, RY, and AJW) who trained together, peer-checked codes, and met weekly to discuss findings. Coding questions were discussed until consensus was reached, and codes were amended as needed. At each interview, JPF discussed with mothers her interpretations of their practices and influences from the previous interview and perceptions of the change that had necessitated the current interview. Mothers had the chance to correct or affirm these interpretations, which guided the rest of the interview. Quotes are presented with pseudonyms and infants' ages when the quote was collected. This work was approved for human subjects research by the Cornell University Institutional Review Board.

## **Results**

Twenty participants were recruited and all pregnancies were carried to term (**Table 1**). In total, 108 interviews were conducted (range 2 – 7 interviews per participant): 102 in mothers' homes, 3 in workplaces at 2 mothers' invitations, and 3 in public for comfort or convenience (**Figure 2**). Participants varied in age, ethnicity, parity, and employment and marital statuses. Except for one mother who left the study because of an unplanned out-of-state move, all mothers remained until 1 year postpartum (n = 12) or HM cessation prior to 1 year (n = 7). Although intention to use HME was not an inclusion criterion, all participants used HME at some point. Mothers used all methods of HME, including single manual, single electric, and double electric pumps, hospital-grade pumps rented from hospitals or WIC, and hand expression (**Table 2**). Eleven mothers used multiple pumps: some replaced or supplemented defective or inefficient pumps, and some working mothers bought second pumps to ease the transportation burdens if pumping both at work and home. Frequently, non-hospital grade pumps were obtained second-hand from family members, friends, acquaintances, garage sales, and unknown online sellers.

### **Attitudes toward and Perceptions of Pumping**

*Mothers' reported reasons for HME.* We present mothers' reasons for HME here insofar as they reflect mothers' attitudes and perceptions of the role of pumps in HM-feeding. Mothers' reasons for HME are described here, and their reasons for feeding pumped HM are described elsewhere (see Chapter 2). In some cases, these reasons were directly related—e.g., in response to latch failure, mothers who wished to feed HM had to both pump and bottle-feed to do so. In other cases, mothers pumped for reasons independent of a specific planned feeding episode, even though nearly all pumped HM was eventually fed to infants. For example, some pumped to

relieve engorgement when mothers and infants were separated or infants were not hungry, and stored this HM for later feeding.

Mothers also described reasons for HME that were not measured in the IFPS II, such as pumping to gauge supply or infant intake (see Chapter 3), to establish their early HM supply, to provide HM to be immediately fed because of a perception that FAB alone was inadequate, or to provide HM to “bottle-train” infants (see Chapter 2). Some mothers also pumped so that they could consume alcohol. These mothers either pumped HM before they drank alcohol so that it could still be consumed by their infants or pumped after they drank and discarded the milk.

*Characterizing mothers’ reported reasons for HME.* Most importantly, mothers’ reasons for using HME changed across the year. This concept is illustrated in **Figure 3**, which shows how reasons for pumping appeared and disappeared over time. Changes in mothers’ reasons for HME over time mainly resulted from the changing success, availability, and desirability of FAB and from mothers’ perceptions of their infants’ current need for HM. For example, HME was used to compensate for latch failure or to establish supply in the earliest weeks. Mothers most often pumped to provide HM for occasional separation or to provide HM to bottle-train infants after supply was established but before regular separation for maternal work. Many mothers pumped provide HM for other caregivers to feed or to maintain supply in the absence of FAB, and most often did so after their return to regular work.

Reasons that women gave for HME could be characterized further as *anticipated* by mothers or *unanticipated*—i.e., whether or not mothers had predicted having to pump for that reason. This dichotomy is also illustrated in **Figure 3**. Some reasons for HME were clearly unanticipated, such as to compensate for FAB difficulty or to relieve engorgement when infants were unwilling or unable to feed at the breast. In contrast, those who pumped to gauge their

supply or their infants' intake typically did not describe a prior intention to do so. Other reasons for HME were anticipated, such to provide HM after return to work. Mothers who pumped to allow other caregivers to bond with infants had usually also planned to do so.

Reasons that mothers reported for HME could also be characterized as *elective* or *non-elective*. This division is also illustrated in Figure 2. Characterization of a reason as elective reflects that mothers opted to pump instead of either feeding at the breast, if it was available, or not emptying their breasts by any means. Non-elective reasons, in contrast, reflect when mothers pumped because feeding their infants at the breast or not pumping were not feasible options. This division was less clear than the dichotomy between anticipated and unanticipated, as electiveness is subjective and because mothers may both want and need to pump for some reasons. Some reasons for HME were clearly non-elective, such as pumping to compensate for latch failure that precluded FAB. However, inasmuch as electivity is subjective, mothers' needs, perceptions, and attitudes guided our characterization of other reported reasons as elective or non-elective. For example, if a mother held negative attitudes toward formula and consequently used HME, we considered this to be a non-elective reason for HME. Most of mothers' non-elective reasons for HME were a direct result FAB being unavailable, e.g. separation from their infant or latch failure, or because mothers believed that FAB or their HM supply were inadequate.

In contrast, when mothers pumped for reasons that did not fill an infant's current need for HM for primary nutrition, we considered those reasons to be elective. For example, HME to provide HM for use in solids or to create a surplus stock for future use were considered to be elective. Many elective reasons for HME related to mothers wanting to share the bonding of feeding infants, or to share the burden of feeding infants because they wanted to sleep or to spend time with other children or on household tasks.

*Characterizing perceptions and attitudes toward HME.* In addition to a reporting a range of reasons for HME, mothers held a wide variety of perceptions and attitudes toward HME. These perceptions and attitudes could be considered in three ways, namely toward HME as a *concept* vs. as a *practice* and toward pumps themselves.

As a *concept*, mothers commonly valued HME as a means of feeding HM in the face of a range of obstacles to FAB that came and went across the first year postpartum, including latch difficulties, public embarrassment, other obligations at home and at work, or emergencies. This value was commonly reflected by mothers who described HME as a reassuring “safety net.” In addition, some appreciated that HME allowed occasional desired time away from their infant that was important to their mental well-being, particularly in earlier months, when infants’ nutrition needs could not be met by feeding solids.

But the pumping also makes you feel a lot more liberated. Like the breastfeeding, I love it, but you also do feel so tied down, you know? And like I could never go anywhere without her. I could never be gone more than an hour on the off chance that she cried. With pumping it does kind of give you that freedom of, you know, that you can do things and you can leave. —Dora, 12 months

Consequently, mothers believed HME was a necessary part of HM-feeding for themselves and others across the infant’s first year, even if they only pumped occasionally and electively. They commonly explained that separation of mother and infant was inevitable, and could occur at any time. They believed that, without HME, this separation would be uncomfortable for mothers or would preclude feeding HM in their absence. Some mothers also appreciated that pumps offered the ability to create large stocks of pumped HM to ensure a longer duration of feeding HM to their infants. However, HME was typically seen as a “means to an end” of providing HM when FAB was unavailable.

I mean, unfortunately it might become one of the primary things, like especially when I go back full-time, but right now I feel like it's just a tool to allow me to keep breastfeeding. Like it keeps up my supply, it gives her enough milk to drink even when I'm not there. But I feel like the breastfeeding is the primary focus.

—Maureen, 5 months

Some mothers voiced displeasure with HME as a concept because they felt it was an intrusion into infant feeding. For some, HME was a source of discord with co-parents or grandparents when they wanted mothers to pump more than she wished to such that they could feed the infant.

Attitudes toward the *practice* of pumping and its related tasks were largely negative, and remained negative across infants' first postpartum year. A dominant theme was that, in contrast to enjoying FAB, HME sessions felt like a tedious chore.

...for me, the formula doesn't really interrupt the part that's more important for me [bonding]. Whereas [pumping] is starting to. Cause it is starting to make it kind of a chore rather than something I can enjoy.

—Mary, 7 wk

Some mothers described physical discomfort, which typically occurred in the earliest weeks that mothers used pumps, and occasionally escalated to blisters or sore or cracked nipples. A few described the irritating noise of the pump. With or without these complaints, many reported feeling that HME at work and home was inconvenient, task-laden, or time-consuming.

And I could not—like for me, I basically had to take time out, sit down, and hold the things in place. I couldn't do anything else. At least that's how I felt when I was doing it. It was just very inconvenient.

— Sarah, 2 months

Mothers who pumped at work commonly reported that it was an inconvenient, unwelcome, or challenging disruption to their workday or to the benefit of their break time. This attitude grew in its influence over mothers' HME intentions and practices as months went by (see *Stopping HME*). Two mothers who were sometimes able feed at the breast at work reported that, compared to HME, FAB caused far less disruption to their workday. Some mothers who pumped at home reported feeling frustrated or tethered while pumping, particularly those with other



children who needed care. In contrast, FAB was seen as time well spent. Thus, mothers typically preferred FAB to HME to empty their breasts for convenience, enjoyment, emotional benefits, or more efficient breast-emptying.

Mothers did not typically perceive that cleaning flanges, tubes, and other parts was difficult, but felt it was a time-consuming chore compared to FAB.

I don't mind pumping, just when I'm really tired, I think it is work. Because you have to then put everything together, you have to wash everything. I don't mind because of course it's for the baby and that's what I want, but I will say, it is work. ...Pumping is a lot of work.  
—Juana, 2.5 months, single electric pump

Some mothers reported difficulties specific to cleaning equipment. These difficulties included a need to wash and dry flanges immediately to permit the next pumping session and difficulty cleaning tubes after HM backed up in them. Some mothers reported that carrying pumps and HME supplies to and from work was a physical burden, particularly with double electric pumps.

Regarding pumps themselves, mothers had strong opinions about the importance of using the highest-quality, double electric pump to produce enough HM in a reasonable amount of time.

I think part of [my low HME yield] was because my pump was only a single boob at a time thing, and WIC just gave me a pump that I could do both breasts at a time. ... definitely much more productive, like much quicker, and I could do both at the same time, and then just kind of get on with everything, which definitely was huge.  
—Georgia, 3 months, rented hospital grade double-electric pump

Mothers who used mid-grade, manual, or single electric pumps reported long HME sessions, delayed or weak letdown, and inadequate suction and yield. Those with single pumps reported “wasted” HM leaking from the opposite breast. Mothers who felt their pumps weren't of high enough quality either bought a better pump or incorporated or increased formula to close the gap they perceived between their pump output and what their infants needed to eat. It was common for mothers to advise other women to invest in the “good pump,” and some felt middle- or lower-

quality pumps weren't worth buying at all. Many mothers felt surprised, stressed, or betrayed at the cost of adequate pumps, bottles, and accessories, as "breastfeeding" was thought to be free.

Most mothers thought infants were more efficient at emptying breasts than pumps. Many said even the best pumps were inferior to infants, and believed this to be an inherent difference.

No. No. No. Uh uh. It's totally different. When she's, when, when I pump, it's like I'm not getting all the milk out. But when, when she, when I'm nursing her and she's on me, she's emptying them out. And, like, it feels so much better because they're not as heavy and they're not as, like, how can I... like [clogged] milk ducts, I don't have the [clogged] milk ducts over here under my armpit, like. —Maya, 3 months

For some women, this attitude reversed later in infancy, but only as the result of older infants' increased interest in other things and consequent distraction while FAB. In these cases, HME sessions could last as long as needed and could finish emptying breasts after FAB.

## **Pumping Practices**

*Pumping while the infant is present.* Mothers pumped with their infants present much less often than they fed at the breast. Mothers only emphasized HME when they had difficulty FAB or thought their HM supply was insufficient. They typically prioritized FAB over HME, and timed their HME sessions for when their infants were asleep or thought to be satisfied.

So I would pump after, you know, like after a [FAB] session. ... And then, if for some reason he didn't wake up in the middle of the night and I did, I would pump then. Or if I was up late studying and he wasn't ready.

—Mary, third trimester, describing HME with her last infant

Mothers pumped at various times relative to FAB sessions. Those who pumped before or in lieu of FAB commonly pumped in the early morning, when their breasts were full enough to leave enough HM for later FAB. Some mothers pumped between FAB sessions to increase supply or store HM for later feeding. Some mothers used HME while FAB, pumping one breast while the infant was on the other breast to facilitate any or enough let-down. These mothers

described difficulty managing both HME and FAB or focusing on both tasks. Here, Theresa describes this difficulty as her husband helped her position baby and pump:

I mean the thing that kinda sucks about it, it's hard to do this like with the baby in one hand and work the pump. So [my husband] helps me a lot of the time. Um, but I try to do it on my own as much as possible. You're almost there, [baby].

Husband: You got it?

Yeah we got it. ... When [husband]'s home I'll sometimes hold [the baby] like this [in a cradle hold]. But when it's just me, I kinda have to use the Boppy so that [the baby] can just lay here and I have a free hand to mess with the pump and stuff. And one time we were sitting here and [husband] was messing with [the pump] and I was trying to fix it on my breast, and [my baby] was like this [laying across my legs] and I didn't have my knees up, and he like almost rolled off, and dad like caught him and it was, it was scary. Yeah, freaked him out, freaked us both out. ... When [husband] is home—I prefer to be holding [the baby] just because he gets more support and there's less flailing around. And after having him almost fall, I don't like having him just sit here. And I've got a really good setup right here, but sometimes when I got the Boppy on, he's up too high for this to be able to be on there comfortably. And also cause I have to like move the boob around all time. So sometimes I don't have a lot of free rein with him up on the Boppy. So yeah, when my husband's home, really he does, like I have him work the pump and change the T.V. channels and stuff. He's the extra hand, yeah, and I don't know what I would do without him. —Theresa, 2.5 months

Finally, other mothers pumped after FAB to finish emptying breasts to increase supply, to store HM, or to produce more HM to be fed immediately from a bottle.

*Pumping while away from the infant.* Mothers who worked outside the home mainly or always pumped at work. These mothers pumped in a variety of locations at work, some of which were pre-established and others created *ad hoc*. Mothers appreciated spaces that were private and/or lockable, such as their own private offices, others' private offices, lactation rooms, and lockable common spaces. They also appreciated employers' efforts to make private pumping spaces comfortable, such as providing rocking chairs. Other mothers pumped in spaces that were visible and/or accessible to others while they pumped. These spaces included shared offices, bathrooms, an open lunchroom and an open supply storage room. Some mothers who pumped in

common spaces reported feeling embarrassed or excluded from coworkers, and many who pumped in bathrooms also reported concerns about cleanliness.

*Equipment cleaning and transportation.* Nearly all mothers washed pump flanges and tubes with dish soap, either by hand or in the dishwasher with other dishes. Many mothers boiled equipment, and two melted and irreparably damaged parts by doing so. Three mothers had HM back up in pump tubes. Two used alcohol to clean these tubes, but for the third, her pump was irreparably damaged by milk backup into the pump itself. At work, mothers commonly washed equipment in common kitchen or bathroom sinks. Some mothers who used these common spaces were concerned about privacy or sanitation. These mothers used wipes or stored pump parts in refrigerators or with ice packs between HME sessions before cleaning parts at home.

*Handling and storage of pumped HM.* Mothers who pumped at work stored HM in private refrigerators, common refrigerators or freezers, or personal coolers. Pumped HM was carried home in coolers to be refrigerated or frozen until it was fed there or transported further to other caregivers. Pumped HM was typically refrigerated beside other food, either in feeding bottles or in interim storage bottles to be combined with pumped HM from later HME sessions. Mothers who froze their pumped HM placed it in storage bags, which were stacked near frozen food, in freezer door shelves, or in plastic bags. Three mothers froze HM in separate freezers.

Mothers prepared and froze pumped HM in various ways. Many who froze HM first refrigerated it. Some of these mothers merged HM from multiple HME sessions into a single container before freezing it. The amount of HM stored in a bag varied from about 2 to 8 ounces. This storage amount was chosen for a variety of reasons. Some mothers stored HM in consistent amounts determined by perceived infant meal size, freezer bag size, or easily divisible numbers. Others stored HM in varying amounts, either because they stored whatever pump output they got

or because they wanted to account for changing infant meal size needs within and across days. Although mothers in this sample used a wide range of practices for preparing and freezing their pumped HM, individual mothers typically did not change their practices over time.

### **Stopping HME**

Mothers who had negative attitudes toward HME sessions reported relief at or eager anticipation of stopping HME, whether or not they described these attitudes as having directly affected their intention to use HME. As described above, mothers' difficulties producing enough HM from pumps created some negative attitudes that influenced the end of HME. As described in detail elsewhere (see Chapter 3), women's other negative attitudes were related to constraints to HME at work. Briefly, these constraints included limited or inflexible time to pump, heavy workloads, or HME spaces that weren't easily accessible. In contrast, mothers were less deterred from HME by a lack of privacy. Mothers who could not pump privately reported that they chose to withstand any discomfort for the sake of providing HM to their infants or avoiding the use of formula. These mothers only stopped HME at work if they believed they'd lost their HM supply or if it became possible to feed at the breast at work.

Mothers' perceptions of the availability of HM and their infants' need for HM also strongly influenced the ending of HME. For many mothers, these perceptions were closely related to how they interpreted the data provided by pumping and bottle-feeding their HM (see Chapter 3). Mothers also assessed the availability of their HM by the perceived adequacy of their current HM supply and the adequacy of their stocked HM to meet their future goals. Mothers' perceptions of their infants' current need for HM were also guided by their infants' age, their perceptions of their infants' health, and their own attitudes toward HM compared to formula.

Mothers who continued or increased HME even though they held negative attitudes about HME or faced constraints to HME were those who believed that their obstacles to HME were surmountable and that their infants' current HM needs were high. Some of these mothers replaced pumps with higher-quality models if they thought new pumps would be helpful and affordable. Mothers who believed that their infants' current HM needs were low, that constraints to HME were insurmountable, or that their own negative feelings toward HME were intolerable, avoided or stopped HME.

### ***Discussion***

This longitudinal, qualitative investigation provides a novel, in-depth glimpse into how and why mothers pump and store their HM. We showed that mothers reported the importance of high pump quality for the success of HME and, thus, HM-feeding. Mothers' reported attitudes toward and perceptions of HME compared to FAB suggest potentially higher risks and burdens for mothers who must rely on HME more heavily to feed HM—e.g., working mothers and those who wish to feed HM but are unable or unwilling to feed their infants at the breast adequately or at all. We showed that mothers' success with HME was subject to many time-, space-, and work-related factors. Taken together, these findings shed light on an inconsistent link between HME practices and HM-feeding outcomes (55, 81, 108, 109). Moreover, some of mothers' reported practices for pumping and storing their HM raise concerns about whether HME affects the benefits conferred to mothers and infants by FAB or introduces other risks.

Mothers viewed HME as an essential to meet their HM-feeding goals, even if they only pumped occasionally. This finding was unsurprising given that all mothers in this sample ended

up pumping, whether or not they had intended to. This finding aligns with national data from IFPS II mothers, as 92% of those who fed HM pumped at some point (56).

Some of mothers' reported reasons for HME reflected their perceptions of HME insofar as these reasons illustrated mothers' perceived need or desire for HME. These data permitted us to characterize mothers' reasons for HME as elective *vs.* non-elective and anticipated *vs.* unanticipated, which suggests potential ways to improve HM-feeding. For example, some non-elective and unanticipated reasons for HME reported here (including difficulties FAB, concerns about HM supply and infant intake, and unavailability of FAB) may be addressed with policy change. Our findings, together with those from the IFPS II, suggest that mothers' reliance on HME to meet HM-feeding goals could be reduced in two ways, namely by increasing mothers' access to help with FAB and providing federally mandated paid maternity leave (59).

Our findings greatly expand on understandings of mothers' reasons for HME. Mothers in our sample cited all of the same reasons for HME that have been reported by IFPS II mothers (56) and mothers in the U.K. (98, 110) and Australia (111). They also clarified and added to these reasons. For example, mothers in this sample and IFPS II mothers commonly pumped to produce HM for another caregiver to feed (56). However, in our sample, other caregivers fed HM for a range of reasons, and that HM had often been pumped by mothers for different, unrelated reasons. These findings suggest that it may not be informative to just ask mothers whether they pumped their HM for another caregiver to feed. Instead, a more complete understanding would result from also asking mothers why other caregivers fed their HM and whether HM fed by other caregivers was pumped for another reason. Mothers in our sample also reported reasons for HME that were not surveyed among IFPS II mothers. Some of these reasons may affect what and how infants are fed in the short- and long-term (such as HME to establish

early HM supply or to create a surplus stock of pumped HM to support long-term goals). These findings are important because they inform the range of reasons for HME that should be included in future surveys.

In this sample, mothers' perceptions of pumps demonstrate the importance of their access to high-quality pumps to succeed in their goals for HME and, thus, feeding HM. Mothers' beliefs that the output from pumps varied widely by pump quality reflect experimental data showing that different pump types yield a wide range of pump output (89, 90, 92, 93). Further, these findings and quantitative analyses reported elsewhere (see Chapter 4) suggest that, in addition to a potential impact of HME on mothers' perceptions of their HM supply, HME may adversely impact mothers' actual HM supply. These results are important because they highlight the importance of making high-quality pumps accessible to all mothers who wish to pump their HM.

Our findings suggest that, compared to FAB, some of mothers' practices for HME and HM storage may affect optimal infant growth and development. Recent data show that donated HM has lower and highly variable fat content and lower energy content than mature HM, which investigators hypothesized resulted from a range in the time of day when milk was pumped (112). It is also known that the macronutrient composition of HM changes during a feed (113). Thus, the range in timing of HME sessions during the day and relative to FAB sessions may impact the macronutrient content of pumped HM. These potential impacts must be studied to ensure that infants receive nutritionally and developmentally appropriate HM. This understanding is critical for optimal infant growth, particularly among those fed a high proportion of their HM intake from bottles and those fed HM that was pumped weeks or months earlier.



Some of mothers' practices for HME, preparing HM for storage, and cleaning pumping supplies also raise concerns about pathogenic contamination of pumped HM as fed. The common use of second-hand pumps is of concern because commercial pumps' open systems are only safely designed for single users. Moreover, either rinsing or wiping pump flanges instead of washing them raise additional contamination concerns. Potential contamination may be magnified among those mothers who mix pumped HM from multiple HME sessions before storage. These findings are troubling in light of recent data that show pathogenic contamination of pumped HM (80, 114). Mothers have no consistent, evidence-based guidelines for hygienic HME and HM storage practices. To create these guidelines, data are needed on pathogenic contamination of pumped HM, pumps, and pump flanges and tubes.

The qualitative work described here has limitations. First, we recruited participants based on their intention to feed HM, not on their intention to use HME, so that we could include mothers who did not plan to pump but did at some point. However, all potential participants had considered and anticipated HME, and all participants pumped. Second, as a result of the Grounded Theory basis of this work, interview guides evolved to incorporate emerging themes. Thus, earlier participants were not explicitly asked about all themes.

This work also has a number of strengths that addressed existing gaps in data. The use of semistructured, open-ended, in-home interviews and observations provided data of great depth and detail about HME. The longitudinal design of this work is unusual in qualitative work. It minimizes reliance on recall and allows observation of the evolution of mothers' attitudes, perceptions, and practices. Last, the diversity and exclusion of mothers who fed only infant formula added measurably to the quantity and breadth of data available from prior work.

## ***Conclusions***

Although national recommendations, campaigns, and policies treat and endorse HME as equivalent to FAB, our findings suggest that HME may not be an adequate substitute for FAB to meet HM-feeding goals. Our findings showed that the success of HME may depend on mothers' access to adequate pumps and, for mothers who work outside the home, workplace support for HME. However, the potential relationships between pump quality and support for pumping at home and at work on mothers' practices for pumping and feeding their HM are not yet measured in national data or addressed fully in national legislation. Further, we showed a range of HME practices that result, in part, from a lack of consistent, adequate advice. Some of these practices raise concerns about whether HME may modify the benefits conferred to mothers and infants by FAB. Taken together, these findings demonstrate the need for data that would inform evidence-based guidelines for pumping and storing HM.

## CHAPTER 2

### BOTTLE-FEEDING HUMAN MILK: A LONGITUDINAL, QUALITATIVE INVESTIGATION OF MOTHERS' REASONS, PERCEPTIONS, ATTITUDES, AND PRACTICES FOR FEEDING PUMPED HUMAN MILK

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## ***Abstract***

**Background.** Most American mothers who feed human milk (HM) now use bottles, cups, or bowls to do so instead of some or all feeding at the breast (FAB). How and why mothers feed pumped HM, and how they understand and feel about these practices are uncharacterized, but they must be understood to investigate their potential implications.

**Methods.** We used ethnographic methods among a diverse sample of mothers who fed pumped HM (n = 20), following each up to 1 year postpartum. Transcripts were coded with Atlas.ti.

**Results.** Infants were bottle-fed HM for several reasons that changed over time, such as mother's absence, latch difficulty, or mothers' desire to bottle-train infants or share the burden and bonding of infant feeding. Regardless of how much mothers used bottles to feed HM, they felt bottles were necessary to meet HM-feeding goals. Almost all pumped HM was fed by non-mother caregivers because mothers typically prioritized FAB for convenience, bonding, and maintaining their HM supply. When feeding styles differed between feeding HM from bottles vs. at the breast, bottles were more often fed at caregiver-led sizes and times. Mothers' methods for storing, transporting, and preparing HM varied substantially and included practices associated with loss of nutrient and microbial contamination.

**Conclusions.** Mothers' reasons for bottle-feeding HM may affect how much they rely on bottles to feed infants. Although mothers commonly felt bottles were necessary to meet HM-feeding goals, the use of bottles may reduce the quality of HM compared to FAB and, thus, may not provide the same benefits to infants as FAB. These findings underscore the need for researchers to investigate relationships between bottle-feeding HM and infant health, growth, and developmental outcomes.

## ***Introduction***

Until recently, women have fed nearly all human milk (HM) by feeding at the breast (FAB). In the U.S., HM is increasingly fed to infants from bottles in place of some or all FAB, and bottle-feeding HM is nationally endorsed (10, 86, 87) as equivalent to FAB. This shift resulted from the congruence of women's need to work outside the home (13-16) and the recent advent of high-efficiency commercial pumps (20). Very little is known about the potential consequences of bottle-feeding HM compared to FAB, yet early data signal potential cause for concern.

Some of these data about feeding HM from bottles come from a national longitudinal survey cohort, the Infant Feeding Practices Study II (IFPS II) (61). However, these data do not clearly differentiate FAB from bottle-feeding HM or survey mothers' reasons for bottle-feeding HM distinctly from their reasons for HME (56). Moreover, the IFPS II surveys did not include questions about how mothers understand or feel about feeding pumped HM. Feeding pumped HM adds a range of tasks related to storing and preparing HM that are not present with FAB. Bottle-feeding HM also provides visual cues (e.g. the quality of HM and the amount and rate of infants' consumption) that are lesser or absent with FAB. It is plausible that mothers' perceptions of and attitudes toward feeding pumped HM may relate to their intended future practices for bottle-feeding HM or infant formula and for FAB. Thus, it is important to characterize women's perceptions and attitudes about feeding pumped HM.

The IFPS II surveys provide data on how much, but not how, mothers feed pumped HM. IFPS II infants who were bottle-fed HM exhibited more bottle-emptying (74) and more rapid weight gain (75) compared to infants who were fed at the breast. It has been shown that the timing and duration of FAB episodes are more infant-controlled, while formula feeds are more

caregiver-controlled (72). It is also known that infants fed at the breast also regulate their intake to match their needs (113), and that infants who are bottle-fed formula consume a greater volume and, therefore, more energy than those fed at the breast (71). Thus, the increased bottle emptying and weight gain among infants bottle-fed HM compared to those fed at the breast may be explained by differences in feeding styles between these two practices. Further, as HM composition changes across the year (113), the length of time between when HM is pumped and when it is fed may affect the developmental appropriateness of HM as fed. Temperature and container changes from storing and preparing HM for feeding may also impact its nutritional, immunological, and pathogenic content (80, 114, 115). Thus, mothers' practices for preparing and bottle-feeding HM must be characterized in detail.

As bottle-feeding HM will likely remain widespread, we aimed fill these gaps in knowledge by collecting in-depth, qualitative data on how and why mothers feed pumped HM. Specifically, we aimed to describe mothers' attitudes and perceptions of, strategies for, and experiences with feeding pumped HM. We included their reasons for feeding pumped HM, how pumped HM feeding is incorporated into their home and work routines and infant feeding choices and practices, and how those perceptions, attitudes, and practices changed over time.

## ***Methods***

We used longitudinal ethnographic methods among HM-feeding women across three counties in upstate New York ( $n = 20$ ). Methods are described in further detail in Appendix A.

*Study Participants.* Pregnant women ( $\geq 21$  years old, singleton pregnancy) were recruited from three counties in New York State from OB-GYN offices, Supplemental Program in Nutrition for Women, Infants, and Children clinics, and infant goods stores, as well as by using

cards distributed in person at these locations and in public and emails sent to parenting email lists. Recruitment was purposive for heterogeneity across factors known to be associated with HM-feeding, such as age, ethnicity, parity, and marital and employment statuses. Participants gave written consent before the first interview, with separate consent for photo and video recording.

*Longitudinal design.* The first interview was conducted during the third trimester to assess prior knowledge, attitudes, perceptions, and intentions for bottle-feeding and FAB. The first postpartum interview occurred at 2 weeks postpartum to allow establishment of FAB and to balance concerns of recall and dyad comfort in a rapidly changing, fatiguing time. Subsequent interviews followed known transitions, such as the start of bottle-feeding, pumped HM-feeding, or solids feeding, mother's return to work, or emergent transitions such as a major shift in employment factors. Mothers were contacted every 2-3 weeks for the first 2 months and every 4 weeks thereafter with a short series of yes-or-no questions, or at other arranged times due to an anticipated transition. Transitions were typically identified within 1-2 weeks, and interviews were typically scheduled within 2 weeks thereafter. Two mothers who experienced regular changes in residence or phone number were difficult to contact in a timely manner. However, both contacted JPF after each change, and only one posed difficulty in scheduling interviews.

*Interviews.* Semistructured, open-ended interviews were conducted exploring knowledge and perceptions of, attitudes toward, and intentions and practices for FAB, pumped HM- and bottle-feeding, and formula- and solids-feeding. Interviews also explored environmental factors and sources of support and information. Multiple interview guides were created to reflect known transitions, including first postpartum, start of pumping, feeding pumped HM or formula from bottles, return to work, and start of solids. Each guide contained the relevant themes plus

transition-specific questions, and were malleable to account for variation between dyads, as transitions may be separate, concurrent, or absent. As not all transitions are anticipated, some interviews contained unplanned topics, such as illnesses that changed feeding practices. Because of the Grounded Theory (106, 107) nature of this work, emerging themes were incorporated into subsequent interviews. Occasionally, non-mother HM-feeding caregivers, such as baby's father or grandmother, and offered information. Interview guides may be found in Appendix B.

Interviews were recorded, transcribed, and checked twice. Field notes were expanded, organized, and typed within 24 hours of interviews. At each interviews, JPF reviewed her interpretations of mothers' practices and influences in the previous interview as well as the changes that had necessitated the current interview. Mothers affirmed or corrected these interpretations, and interviews proceeded according to her responses. Predetermined and emerging themes were examined with content analysis using open- and closed-coding in Atlas.ti (Berlin, Germany). Coding was ongoing and iterative to examine responses to predetermined themes, to guide subsequent interviews, and to identify emerging themes. Coding was shared by four co-authors (JPF, CWQ, RY, and AJW). They trained together, peer-checked codes, and met weekly to discuss findings. Coding questions were discussed until consensus was reached, and codes were amended as needed. All quotes are reported with pseudonyms and by the infant's age at the time of quote collection. This work was approved for human subjects research by the Cornell University Institutional Review Board.

## ***Results***

Twenty participants were recruited and all infants born at term. In total, 108 interviews were conducted (range 2 – 7 per participant): 102 in mothers' homes, 3 in workplaces at 2



mothers' invitations, and 3 in public for comfort or convenience. Mothers varied in age, ethnicity, parity, employment and marital status, and prior experience with FAB and bottle-feeding (see Chapter 1). Except one participant who exited because of an unplanned move, all mothers remained until 1 y postpartum (n = 12) or HM-feeding cessation prior to 1 year (n = 7). Although intention to feed pumped HM was not an inclusion criterion, all infants were bottle-fed HM at some point.

### **Why Mothers and Caregivers Fed Pumped Milk**

*Reasons for pumping HM vs. feeding pumped HM.* We present mothers' reasons for pumping HM elsewhere (see Chapter 1) and their reasons for feeding pumped HM here. In some cases, these reasons were parallel—e.g., in response to latch failure, mothers must use both pumps to obtain and bottles to feed their HM. Thus, some of mothers' reported reasons for bottle-feeding HM reflect reasons for pumping. However, some infants were bottle-fed for reasons that did not relate to why mothers had pumped that HM. For example, some mothers pumped to relieve engorgement, but that HM was later fed by fathers to promote bonding.

The most important determinant of feeding pumped HM was the unavailability of FAB. In early infancy, FAB was most often unavailable because of latch problems, which led four mothers to rely primarily or solely on bottles to feed HM. Three of these never established FAB and stopped HM-feeding between 4-7 weeks. One, who did not work outside the home, was able to establish FAB, and fed HM beyond 1 year. After early infancy, employment outside the home was the most common reason that FAB was not available.

*Types of reasons.* We characterized reasons for bottle-feeding HM as *elective* or *non-elective* and *anticipated* by mothers or *emergent*. These reasons are illustrated in detail in **Figure**

4. As described elsewhere (see Chapter 1), we used mothers' perspectives to make these subjective designations. For example, we considered bottle-feeding HM elective when it was used to share the bonding opportunities or burden of HM-feeding with other caregivers . In contrast, we considered bottle-feeding HM non-elective when FAB was unsuccessful, unavailable, or thought to be inadequate. Some bottle-feeding of HM was emergent, such as latch failure or unexpected separation. Other bottle-feeding was anticipated, such as when mothers used pumped HM to bottle-train infants in advance of returning to work.

*Reasons for what is fed from bottles.* Mothers commonly preferred bottle-feeding HM to formula because they thought it was better for infant health and cost less. Some mothers chose to feed formula themselves when pumped HM was available. They did so to avoid having to pump more HM, to save HM for other caregivers to feed, or because they thought their infants might not finish bottles and, thus, might waste leftover HM. Mothers' perceptions of infant need for HM vs. formula impacted the content of bottles. For example, when mothers perceived their infants' need for HM as low because their infants were older or in robust health or because they thought formula was an acceptable substitute for HM, they increased use of formula.

### **How mothers perceive and feel about feeding pumped HM**

In parallel to their perceptions of and attitudes toward pumping their HM, mothers' perceptions of and attitudes toward bottle-feeding HM were toward it as a *concept*, i.e. in its role in HM-feeding, as a *practice*, i.e. its related tasks, or to bottle-feeding *sessions*. Mothers' attitudes and perceptions changed over time because of their other obligations, perceptions of their infants' current need for HM, and attitudes toward pumping and formula.

*The concept of pumped HM feeding.* All mothers felt that, to avoid or reduce formula use, pumped HM was necessary for the inevitable times when FAB was unsuccessful, unavailable, or undesired. Mothers also felt that pumped HM had an important role in allowing them to share the bonding and responsibility of infant feeding with other caregivers. A few appreciated pumped HM as an option because of their anxiety about FAB in public or desire to provide their infants extra nutrition or immunologic benefit in solids or sippy cups.

Between and within mothers, attitudes about relying on other caregivers and, thus, bottles to feed HM contrasted. Some mothers reported feeling discomfort at sharing the responsibility and decision-making of HM-feeding with other caregivers.

I, being at home now for, you know, a month and a half or so I've been home, I am so, I feel like I am so much more in tune to him. Because then, it was like somebody else was making his schedule, and I'm asking them, 'When does my baby eat?' And I didn't like that, you know, but I had no control over it. Um, and I felt like he was eating, like he was having, he was eating when I didn't feel like he needed to be eating. ... Um, and so now that I've been home, I feel like I'm much more in tune to what he needs to eat, and I set the schedule now, so what I feel like is best for him and works best for us.

—Avery, 9.5 months

Two mothers, in contrast, enjoyed the regular reprieve from these responsibilities. Mothers' perceptions of the benefits to infants of bottle-feeding HM also differed. Many mothers felt that bottle-feeding HM was equivalent to FAB. Others felt that bottle-feeding HM did not provide the same bonding as FAB or conferred a higher risk of overfeeding and overweight than FAB.

*The tasks of pumped HM feeding.* Mothers' attitudes and perceptions toward preparing and feeding pumped HM were direct determinants of her preferences among FAB, bottle-feeding HM, and bottle-feeding formula. These attitudes and perceptions were commonly negative. Most frequently, mothers found the tasks associated with feeding pumped HM to be time-consuming, but not difficult, chores.

It's like the easiest—you know, it's just so easy to nurse. You don't have to worry about the bottle. Like, I mean, I keep saying that you don't have to worry about the bottles and making sure everything is clean. And you know, that once a night, I don't have to worry about stumbling over god knows what out there while I'm trying to make a bottle to feed her.  
—Catherine, 5 months

Mothers who described preferring FAB commonly cited its bonding and emotional benefits as reasons for this preference. When mothers preferred bottle-feeding HM to FAB, these preferences were typically episodic and in response to situational constraints.

*Pumped HM feeding sessions.* Mothers' perceptions of the feeding episodes themselves either related to bottle-feeding HM vs. formula or to feeding HM from a bottle vs. at the breast. Some mothers perceived that HM was thinner and less satisfying than formula. Two mothers with this perception responded by putting more pumped HM in bottles than they did when they fed formula. Mothers also commonly thought that the flow of HM was faster from bottles than from breasts. Sometimes this perception resulted from observing infants' increased effort, time, or frustration while FAB compared to bottle-feeding. Other mothers learned from friends, family, or the internet that there was a difference between bottles and breasts. Some responded to this perception by burping infants in the middle of bottle feeds, using low-flow nipples, prioritizing FAB when available, or telling caregivers that infants didn't have to finish bottles. Others concluded that FAB was inadequate or unsatisfying for infants, and responded by substituting or supplementing FAB with bottle-feeds.

### **How infants were fed pumped human milk and fed from bottles**

Across their infants' first year, mothers fed pumped HM in place of FAB to a widely varying degree, from never to as a sole source of HM or as the sole food. Pumped HM was typically bottle-fed but, later in infancy, it was occasionally fed from cups or mixed with solids.

*Preparation of pumped HM to feed.* Mothers' strategies for transporting and storing HM, and, thus, the number of temperature fluctuations and container transfers, affected the pumped HM that was fed to infants (**Figure 5**). How mothers handled pumped HM depended on when they expected to feed it. In most cases, pumped HM to be fed within a day or two was kept refrigerated, while HM intended for later feeding was frozen in bags. Daycare providers typically kept the day's HM refrigerated, but sometimes accepted larger stocks of frozen pumped HM. A few mothers kept HM frozen at family members' homes as extra stock or to be fed there.

The number of pieces of equipment that HM contacted before being fed to infants ranged from two, when HM was pumped directly into a feeding bottle from a hospital-grade pump, to six, when HM was pumped with a commercial pump into a bottle, refrigerated in another, frozen in a bag, and fed from a bottle or sippy cup (**Figure 5**). Changes to the temperature of HM before it was fed to the infant ranged from none, where HM was fed immediately after it was pumped, to five or more. Mothers and other caregivers thawed frozen HM at room temperature or by placing bags in hot water, and warmed refrigerated HM by placing bottles in hot water, a bottle warmer, or a microwave. Some mothers tried to minimize loss of nutrients in HM by thawing it more slowly or by storing it deeper in freezers. If infants did not finish bottles, some mothers thought HM was contaminated and disposed of it. Others, who did not want to waste HM, kept it refrigerated or at room temperature until it was fed later.

Like if he'll stop, sometimes he'll go back to sleep for another hour or two, and then we just pull out that same bottle and use it. Cause I do not want to waste any of the milk that takes me so long to get.                      –Theresa, 2.5 months

*Who feeds pumped HM.* Nearly all pumped HM was fed by non-mother caregivers. Mothers who fed pumped HM themselves typically did so because FAB was unsuccessful or uncomfortable or because they felt FAB was inadequate to meet their infants' needs.

So like in the hospital, like babies gonna lose a certain percentage, but he lost a little bit more, 2% more. I think it's our breastfeeding battle we were having. ... [On day three, the pediatrician said], like, 'Well, this, let's try [pumping],' because I didn't really want to supplement with formula. No. And so I cried for that, too. ... So I had to start pumping early, and give him whatever remaining, feed him and then pump whatever's left in my boob, and then give him that. ... And I was like, it's crazy, because in the beginning, I started and there was lots of milk left, and then afterward, like with me stuffing him with the leftovers, it's like, he started just naturally eating all of it, well, mostly all of it by himself. ...he'd eat in a second.                      –Linda, 3 weeks

Otherwise, mothers typically preferred and prioritized FAB. Infants' fathers or other family members occasionally fed HM to share the bonding and burden of feeding. After return to work, outside caregivers, who sometimes included extended family members, fed most pumped HM.

*What is fed with pumped HM.* Until late infancy, pumped HM was only fed from bottles. Some infants were only fed HM from bottles. Among infants fed both formula and HM from bottles, some were fed formula as a supplement to bottles that mainly contained HM. Other infants' needs were substantially or mostly met with formula. Mothers of these infants mixed small amounts of pumped HM into formula bottles because they perceived any amount of HM to be beneficial to infants.

I would pump it into the little holding containers and put it in the fridge if it wasn't time for him to eat. And if I had enough, if I had pumped enough at that time—because I ended up only pumping like three or four times a day—I would, we would just feed that, or we'd just add formula to it to get the two to three ounces.                      –Sarah, 2 months

One mother would not mix formula with HM so as to maintain the purity of HM, and alternated bottles of HM and formula. A few mothers mixed pumped HM with infant cereal or homemade infant food to improve its nutrition or palatability. A few others fed pumped HM from sippy cups late in infancy, either to train infants to use sippy cups or to avoid using bottles.

*How much HM is fed.* The amount of HM in bottles depended on the purpose of that bottle-feed. When bottled HM was fed as a supplement within a meal, bottles contained a nominal amount of about 1-3 oz. and infants were typically permitted to stop as they wished.

Bottle amounts were larger when bottled HM was fed as a meal in place of FAB; which reflected mothers' perceptions of their infants' needed meal size. In addition, non-infant factors affected the amount of HM—with or without formula added—that mothers put in bottles that were fed as meals. These factors included the needs of older siblings, intuition, formula instructions, pump output, and when mothers wanted the next meal to occur.

The amount of HM and/or formula fed from bottles was commonly constant across feedings, and only changed when mothers perceived that their infants' needs had increased. Among those who fed consistent amounts across feedings, some mothers and caregivers used infants' behaviors to determine meal size. They did this either by stopping feeds when infants no longer seemed hungry, continuing feeds until infants refused bottles, or making a second bottle if infants still “seemed hungry” after the first. Mothers then used this total amount to guide subsequent bottles. Mothers who varied bottle sizes episodically were those who relied on FAB for most HM feeding or were confident in their infants' capacity to eat as much as they needed. Mothers who felt comfortable with other caregivers choosing the amount to put in bottles reported the same confidence in their infants or in the caregiver's capacity to read infant cues.

[I deliver pumped HM to the caregiver] right in the bags, because I figured, you know, it varies a lot because of how much she drinks [while FAB], so it's going to vary how much she's going to drink during the day, too. So there'll be times when she just needs a little bit, or sometimes she needs more, you know. Maybe she'll start off with a big one and really still be thirsty, then she could have a little one, you know, or something. So, um, I just gave them the bags as is. —Flora, 3 months

When mothers and outside caregivers put different amounts of HM and/or formula in bottles, mothers commonly described choosing the amount by their perception of infant need. Some were concerned that caregivers overfed their infants because they could not read infant cues as well as mothers could. Some mothers fed the same amount as other caregivers, regardless

of how the amount was chosen. Of these mothers, three had adopted the amount chosen by other caregivers.

He wasn't really even wanting to drink [the bottle], like you had to encourage him. Well, I didn't, the babysitter had to encourage him to drink like the six ounces. And so, my babysitter, she's, she's funny. She likes to take charge, I guess. ... So she came up with a whole new schedule for him that we just started like two days ago. He's now drinking like a four-ounce bottle here with some cereal, and then—I don't know, I have her schedule written out, I don't even know it myself. —Avery, 7 months

*Initiation and ending of pumped HM bottle-feeds.* How mothers and caregivers chose the timing of bottle feeds varied, and commonly differed by breast vs. bottle. FAB was typically on demand, except early postpartum, when mothers sometimes woke young infants to eat or fed them frequently to stimulate their HM supply. In contrast, while some mothers and caregivers bottle-fed on demand, bottle-feeding episodes were more likely to be initiated by mothers or caregivers than FAB episodes. Moreover, many mothers implemented set feeding schedules, and were more likely to do so if they relied heavily on bottles. For example, infants of working mothers, who were regularly bottle-fed HM by other caregivers, were more likely to be fed on schedules. These schedules sometimes began well ahead of return to work. Mothers cited many other reasons for feeding on schedules, which are described further elsewhere (see Chapter 3).

How the end of a feeding was determined also varied; it depended on whether HM was fed at the breast or from a bottle. Infants typically ended FAB episodes by pulling away or falling asleep. Some mothers ended FAB sessions when they felt their infants had finished eating. In contrast, caregivers more often determined the end of bottle-feeding episodes, which they gauged by an empty bottle. Mothers who allowed infants to end feeding episodes before bottles were empty reported confidence in their infant's ability to consume as much as needed. Some mothers noted that, although infants did not finish bottles with them, caregivers reported



consistent bottle emptying. This report was a common, and sometimes the only, impetus for increasing bottle size.

Well, [the increase in meal bottle size] wasn't so much me. It was that the sitter was saying 'He's really chugging his bottles, you know, he's really just downing them and acting like he could go for more.' And I said, 'Well then test it out with him!' You know, like, 'Instead of four, give him, give him, give him five. If he does five, you know, eventually, and he's acting hungry still, give him six.' So we went from three 4-ounce bottles... to four 4-ounce, and then it was three or four 5-ounce, and now he's doing like, I think like three 6-ounce bottles. —Kerry, 6 months

In most cases, infants who began finishing their bottles continued to do so. If mothers were unable or unwilling to pump more to meet their infants' increasing needs with pumped HM, regular bottle emptying with caregivers led to starting or increasing formula use.

Um, so I said, 'Start cutting in a little formula.' Like, I, we had tried formula with him before, I knew he wasn't allergic or anything, so ... the first day she started mixing in formula was last week, and she did three ounces of milk and one ounce of formula, and he took that very well, she said. And then she started doing two and two. —Kerry, 6 months

Responsiveness of feeding differed not only by whether infants were fed HM at the breast or from a bottle, but also by the context in which HM was bottle-fed. Infants were bottle-fed HM more responsively with mothers present at home, whether or not mothers bottle-fed infants themselves, than with other caregivers away from home. Some infants who were fed on schedules with other caregivers were bottle-fed on demand at home.

[The daycare providers feed a bottle] every two hours. And so we told them, 'Oh you only need to feed her when she's fussy, that's when to feed her. She gets fussy you'll be able to tell.' But it's every two hours. And when you go to her little information sheet, they're like, '[baby] likes to eat every two hours.' So, we're like meh, it works. ... I think they just like everything on a schedule. —Dora, 6 months

When bottles were fed as meals in place of FAB at home, they were more likely tailored in size to mothers' or fathers' perceptions of their infants' needs, and infants were more likely to be allowed to leave bottles unfinished. For three mothers, their infants' grandmothers were notable

exceptions to responsive bottle-feeding at home. Mothers reported that these grandmothers overfed infants or encouraged bottle-emptying. None of the three mothers discussed these concerns with grandmothers, and one adopted the grandmother's chosen amount despite her concerns because she felt she was too uninformed to disagree.

## ***Discussion***

Mothers in this sample described a wide range of practices by which they and other caregivers prepared and fed pumped HM to their infants. Styles for bottle-feeding HM were less responsive than styles for FAB, and practices for preparing HM before feeding it to infants included a range of changes in temperature and container. Mothers in our sample described a wide range of reasons that they both wanted and needed other caregivers or themselves to feed pumped HM to their infants instead of feeding them at the breast. Most mothers felt that feeding pumped HM was necessary to meet overall goals for feeding HM, and appreciated it as an option when FAB was unavailable. However, they found the practice itself to be more burdensome and less rewarding than FAB. Taken together, these findings make an important contribution to the emerging literature on feeding pumped milk to infants.

Our findings provide a detailed characterization of mothers' reasons for bottle-feeding HM—or, more likely, having other caregivers bottle-feed HM. Our limited prior understanding of mothers' reasons for feeding pumped HM comes from qualitative data from IFPS II mothers (56) and mothers in the U.K. (98, 116) and Australia (111). Specifically, IFPS II surveys measured mothers' reasons for pumping, not bottle-feeding, their HM (56). Our findings suggest that some of the reasons IFPS II mothers indicated that they pumped their HM were more likely reasons that they fed pumped HM. In our sample, it was rare for mothers to choose to pump

because they did not want to feed at the breast or because it was too painful to do so. Instead, this was usually a feeding choice that needed to be made—i.e. to feed from a bottle rather than at the breast. Further, mothers who bottle-fed HM because they did not want to feed at the breast felt that way for differing reasons, such as wanting to focus on other children in that moment or because they did not like FAB. Additional possibilities identified here might have different implications for long-term HM-feeding outcomes. Thus, our findings illustrate that reasons for feeding pumped HM should be surveyed separately from reasons for pumping HM.

Moreover, the reasons that mothers reported that they and other caregivers bottle-fed HM suggest potential ways to optimize infant feeding and thus, health, growth, and development. In this sample, infants were bottle-fed HM for many evolving reasons that could be characterized by how much they were *anticipated* and *elected* by mothers and caregivers. *Unanticipated* bottle-feeding is of concern because it may represent modifiable problems with or constraints to FAB. *Non-elective* bottle-feeding is of concern because mothers who would have chosen FAB if it had been available may be at higher risk for using formula if they do not highly value HM at that time or if they have difficulty providing enough pumped HM. Future quantitative research must clearly distinguish FAB from bottle-feeding HM and measure a full range reasons for mothers' chosen methods for feeding HM.

Mothers described a range of attitudes that illustrated generally positive feelings toward the *concept* of feeding pumped HM yet predominantly negative feelings toward its *practice* when they bottle-fed HM themselves. Some of mothers' positive attitudes toward the *concept* of feeding pumped HM were reflected in their reasons for feeding pumped HM. In contrast, their negative attitudes toward the *practice* of feeding pumped HM were directly related to their typical preference for FAB if it was available. These findings are important because they raise

concerns about the infants of mothers who are unable to rely on FAB as much as they would prefer. These mothers may be more likely to feed formula instead of HM from bottles because of greater disruption to their other obligations at home and at work or. Further, our findings highlight that attitudes toward FAB and bottle-feeding HM should be investigated separately to understand how they affect mothers' intentions and practices for feeding their infants.

Mothers' descriptions of how their infants were fed pumped HM raise concerns about HM-feeding and infant growth outcomes across the first year. In this sample, bottle-feeds were more caregiver-controlled than FAB sessions. Responsive feeding is important to meet infants' needs, which vary within a day and over time (113). Mothers who bottle-feed formula feed less responsively than those who feed at the breast (72, 117, 118), and formula-fed infants consume more energy and volume in a feeding (71) and exhibit more rapid growth and weight gain than those fed at the breast (31, 32, 119). In the IFPS II, infants who were bottle-fed at high intensity—whether HM or formula—had impaired self-regulation of intake (74) and faster weight gain (75) by the end of the first year than those fed at the breast. Our findings suggest that the more rapid weight gain associated with bottle-feeding HM compared to FAB may result from caregivers bottle-feeding infants with low responsiveness or by the solutions that mothers use to meet their perceptions of their infants' needs. Further, our findings support a recent clinical practice statement (78) that raised concerns about caregiver-controlled, amount-oriented bottle-feeding of HM and its potential impacts on infant growth. As a result, it is important to investigate styles for FAB and bottle-feeding HM to understand their potential links to infant growth outcomes.

Mothers' reports of how HM was handled before it was fed to infants raise concerns about the nutritional and developmental appropriateness of pumped HM in three ways, echoing

concerns raised by others (74, 75, 77, 80, 112, 114, 115). First, in this sample, pumped HM went through 0-5 or more temperature changes. Recent data show that long-term freezing of pumped HM may lower its fat content and energy (115). Second, the length of time between when HM was pumped and when it was fed ranged from minutes to months. The macronutrient and immunological composition of HM changes across a year to meet infants' current needs (113). Thus, some infants in this sample were fed HM that met their needs weeks or months earlier. Data are now needed to quantify the effect of various pumping and bottle-feeding practices on the nutritional and immunological integrity and developmental appropriateness of pumped HM as fed.

Third, our finding that pumped HM comes in contact with 2-6 containers before feeding is important because it may partly explain recent data showing widespread pathogenic contamination of pumped HM (80, 114) and increased coughing and wheezing among infants bottle-fed HM compared to those fed at the breast (120). Data are needed to investigate the potential links between bottle-feeding HM and infant infections and illnesses.

The qualitative investigation presented here has limitations. First, in this sample, the majority of bottle-feeding HM was conducted by non-mother caregivers. In addition, the amount of non-mother feeding of HM increased with degree of dyad separation because of maternal employment. Consequently, practices for bottle-feeding HM were primarily reported by mothers, but their knowledge of practices ranged from none to complete, and for mothers who fed at the breast, we observed minimal or no bottle-feeding. This limitation in our data reflects an important shift in the decision-making power of feeding HM, which is now shared among multiple caregivers. Consequently, to understand practices for bottle-feeding HM, qualitative

data similar to those reported here and epidemiologic data similar to the IFPS II should be collected among non-mother HM-feeding caregivers.

Second, participants were recruited based on their stated intention to feed HM and having thought about pumping and bottle-feeding HM. In theory, we excluded mothers who had not heard of or considered these options but used them anyway. However, of mothers we identified based on their intention to feed HM, all had considered and anticipated feeding pumped HM.

Last, because this work was based on Grounded Theory, we modified interview guides over time to incorporate emerging themes. Thus, earlier participants were not explicitly asked about some themes. For this reason, and because of the still-small sample required of this longitudinal, in-depth qualitative work, important themes identified in this work must be investigated systematically using surveys among larger and more representative samples.

This work has a number of strengths that act together to fill prior gaps in qualitative data on HM-feeding. This work is the most comprehensive qualitative investigation of HM-feeding yet conducted, and the only qualitative investigation of feeding pumped HM, a behavior that has become widespread in the U.S. The use of semistructured in-home interviews and observations provided is with data of great depth and detail about infant feeding. The inclusion of open-ended questions on mothers' attitudes toward, perceptions of, and experiences with infant feeding provide unprecedented opportunity to understand mothers' reasoning for and responses to their infant feeding practices. Our longitudinal design is unusual in qualitative investigation of HM and the duration of our observation of these mothers was unprecedented. It minimized mothers' reliance on recall and allowed real-time observation of the evolution of mothers' attitudes and perceptions and their short- and longer-term impact on practices.

## ***Conclusions***

In this longitudinal qualitative work, we have illustrated a number of differences between FAB and bottle-feeding pumped HM that raise concerns and important questions about the growth, health, and development of infants fed HM from bottles rather than at the breast. Mothers' reported perceptions of and attitudes toward bottle-feeding HM suggest that infants of mothers who rely on bottles to a higher degree due to difficulty with FAB or employment may be at greater risk of being fed formula instead of HM. Taken together, these findings are a call to researchers, clinicians, and policymakers that bottle-feeding HM and FAB should not be treated and endorsed as equivalent practices and that many research questions about bottle-feeding HM must urgently be addressed.

## CHAPTER 3

### PUMPING AND BOTTLE-FEEDING HUMAN MILK: HOW MOTHERS PLAN FOR, PREPARE FOR, UNDERSTAND, AND ARE SUPPORTED IN HUMAN MILK-FEEDING COMPARED TO FEEDING AT THE BREAST

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## ***Abstract***

**Background.** Although most U.S. mothers who feed human milk (HM) now also use pumps and bottles to do so, little is known about how they understand and experience pumping and bottle-feeding HM.

**Methods.** We used ethnographic methods among a diverse sample of 20 mothers who pumped and bottle-fed their HM to their infants. We conducted semistructured interviews and observations from late in pregnancy until the end of all HM-feeding up to 1 year postpartum. Emerging themes were examined further with content analysis.

**Results.** Here, we present three comparative case studies to illustrate relevant findings. Pumping and bottle-feeding HM required a range of tasks and considerations that are either absent or reduced when feeding at the breast. Mothers interpreted data from pump output and speed and also bottle intake amount and speed to understand their infants' needs and their ability to meet them using pumps. The support that mothers received from their partners and employers was important to their ability to manage their tasks and considerations and, thus, their goals and practices for HM-feeding.

**Conclusions.** We found that pumping and bottle-feeding HM, compared to feeding at the breast, require time, resources, discomfort, and thought in ways that may hinder mothers' short- and long-term HM-feeding goals. Our findings suggest that health professionals, partners, and employers all have potential roles in supporting pumping and bottle-feeding HM that may lessen this impact.

## ***Introduction***

In the U.S., practices for feeding human milk (HM) have shifted substantially so that feeding at the breast is now increasingly being replaced by mothers pumping HM from their breasts and bottle-feeding it to their infants. Among HM-feeding women in a national survey cohort, the Infant Feeding Practices Study II (IFPS II), 92% pumped their HM at some point in their infant's first year (56, 109, 121). Many of these women pumped their HM regularly, and some only fed HM from bottles. This shift may affect both maternal and child health outcomes that underpin HM-feeding recommendations. Pumping and bottle-feeding HM are nationally recommended, endorsed, and promoted as equivalent to feeding at the breast (10, 86, 87) to optimize these health outcomes. However, despite the frequency with which pumping and bottle-feeding HM have been incorporated into mothers' infant feeding practices, almost nothing is known about how mothers understand and think about these practices. This knowledge is critical for understanding these potential consequences of pumping and bottle-feeding HM.

Previously, we used ethnographic methods to characterize others' attitudes, perceptions, and practices for pumping and bottle-feeding HM (see Chapters 1 and 2). Mothers reported a range of practices, including acquiring and using pumping equipment and storing, preparing, and bottle-feeding HM. Mothers allocated the resources available to them, including time, space, and money, to these practices. They did so while balancing their goals for HM-feeding with their work and home obligations. It is unknown how mothers conceive of and address these considerations or how doing so may affect their daily lives and intentions for pumping and feeding their HM in the future. Further, although it is known that support from partners (122, 123) and employers (124, 125) is important for achieving women's goals for feeding at the breast, the role of support from partners and employers in pumping and bottle-feeding HM are

unknown. Given the high prevalence of pumping and bottle-feeding HM, this gap in knowledge is important because any potential impacts would have national implications for public health.

Further, pumping and bottle-feeding HM may affect mothers' perceptions of their ability to meet their infants' HM needs. Mothers' self-efficacy for feeding at the breast is an important predictor of their HM-feeding intentions and practices (49, 50, 62). Mothers' self-efficacy is closely related to their perception of their HM supply and, thus, their capacity to meet their infants' HM needs. It is also known that mothers' perceptions that their HM supply is inadequate predict shorter—and shorter than desired—HM-feeding duration (60, 82). Mothers who feed only at the breast may use perceived infant satiety and growth adequacy to assess the sufficiency of their HM supply. Mothers who use pumps and bottles to feed HM have access to information about their HM production from this process, and may use this information as an additional way to assess the sufficiency of their HM supply.

Pumping and bottle-feeding HM may also be associated with understandings of and practices for HM-feeding that differ from those associated with feeding at the breast. Mothers feed formula less responsively than mothers feeding at the breast because they exert more control over the timing and size of feeds (72, 117, 118). In IFPS II, infants bottle-fed HM exhibited diminished self-regulation (74) and more rapid weight gain (75) compared to those fed HM at the breast. These data suggest that the addition of pumps and bottles to HM-feeding may be linked with more use of non-infant cues to ascertain infant need. Mothers' understandings of how HM is fed from bottles compared to at the breast, and how this understanding may be associated with their practices and intentions for pumping their HM and feeding it by bottle or breast, are unknown.

Emerging data from our longitudinal qualitative study of mothers using pumps and bottles to feed HM to their infants showed that these are important gaps in knowledge (see Chapters 1 and 2). Recent qualitative work by others on pumping (126) suggests how mothers' pumping and bottle-feeding practices may relate to their concerns about how much their breasts produce from pumping, how much their infants consume from bottles, and how mother-infant bonding may be disrupted. Another *post hoc* analysis of a small sample of mothers showed that they perceive pumps as a means of meeting competing demands as mothers and employees (116). However, these reports come from a context with dramatically more support for working mothers—specifically, the U.K, which provides maternity leave of 12 months, 9 months of which are paid at 90% salary (127). Thus, these data do not reflect the experiences of mothers in the U.S., who must return to work much earlier and continue to provide HM for their younger infants. In addition, in a review of how pregnant and lactating mothers are treated in the workplace, the authors touched only briefly on pumping and did so through the lens of employer support for HM-feeding, again, focused on U.K. contexts (128).

Thus, the psychological experiences of pumping and bottle-feeding HM—namely, the collection of tasks and concerns mothers must consider and their understandings of feeding HM—are largely absent in the literature. In response to emerging themes from our ethnographic work—which, in contrast to the U.K. research described above, was specifically targeted to pumping—we conducted targeted analyses to examine these themes further. Specifically, we aimed to describe the preparations, tasks, and thought processes related to pumping and bottle-feeding HM that are not present with feeding at the breast. We also aimed to understand how these preparations, tasks, and thought processes may impact mothers' understandings of their infants' needs and their ability to meet them with their HM supply.

## ***Methods***

We used longitudinal ethnographic methods to study mothers who pumped and bottle-fed their HM in place of some or all feeding at the breast in three counties in upstate New York (n = 20). Methods are described in greater detail elsewhere (see Chapters 1 and 2 and Appendix A).

*Study Participants.* Pregnant women ( $\geq 21$  years old, singleton pregnancy) were recruited from three counties in New York State. Mothers were purposively recruited to represent a range of factors known to be associated with HM-feeding, such as ethnicity, parity, age, and marital and employment statuses. Participants provided written consent before the first interview.

*Longitudinal design.* Prenatal interviews occurred during the third trimester to assess prior knowledge, attitudes, perceptions, and intentions for feeding at the breast, pumping, and bottle-feeding HM or formula. The first postpartum interview occurred at 2 weeks after mothers delivered to allow mothers time to establish feeding at the breast while not waiting so long that recall bias was a concern. Any interviews scheduled thereafter were specific to transitions experienced by the dyad, such as the start of pumping or bottle-feeding, the introduction of solids, or mother's return to work. Mothers were contacted regularly to inquire about changes that had occurred or at prearranged times to ask about an anticipated transition. Interviews were scheduled to follow any reported transition.

*Interviews.* Semistructured, open-ended interviews all included questions on main themes, such as knowledge and perceptions of, attitudes toward, and intentions and practices for feeding at the breast, pumped HM- and bottle-feeding, formula- and solids-feeding. Interviews also included questions specific to the most recent transition, and were malleable to account for when dyads experienced transitions separately, concurrently, or not at all. As themes relating to

mothers' considerations for and understandings of pumping and bottle-feeding HM—both alone and compared to feeding at the breast—emerged, questions and codes were created for targeted analyses of these themes. These codes were primarily proposed by JPF, who conducted interviews, with additional code suggestions and feedback from three other team members, CWQ, RY, and AJW. Codes were constructed, tested, and discussed until consensus was reached, and amended as needed. Interview guides can be found in Appendix B.

Audio recordings of interviews were transcribed and checked twice and field notes were expanded, organized, and typed within 24 hours of interviews. Transcripts were de-identified using pseudonyms. We examined relevant themes with content analysis, using ongoing and iterative open- and closed-coding in Atlas.ti (Berlin, Germany). Coding was shared by four team members (JPF, CWQ, RY, and AJW). Quotations are identified by pseudonyms and the age of participants' infants at the time the quotation was obtained. This work was approved for Human Subjects Research by the Cornell University Institutional Review Board.

## ***Results***

Three mothers—Maureen, Avery, and Kerry—are described in detail here. They have been selected from our larger sample, in part, because they all worked full-time outside the home and wished to minimize formula use and, thus, relied on pumps and bottles regularly. Although three mothers cannot show the full range of our observations, these three had contrasting home and work contexts and prior experiences with pumping and bottle-feeding their HM and with feeding their infants at the breast. These differences related to their considerations, interpretations, intentions, practices, and support for pumping and bottle-feeding their HM.

Maureen's job and employer afforded her flexibility in her return to work and her work schedule and responsibilities after she did return to work. She also benefited from the substantial help of her husband, who took a major role in feeding solids and bottled HM and in cleaning pumping and bottle-feeding equipment. However, the spaces available to her to pump and wash her pumping equipment were difficult to access and visible to others.

Avery, like Maureen, was also married and returned to full-time after about 8 weeks. However, unlike Maureen, Avery's husband offered little to no help with feeding HM or solids to their infant or managing the equipment needed to do so. She also had a rigid work schedule that dictated when and for how long she could pump. However, also unlike Maureen, Avery benefited from easily accessible spaces to pump her HM and clean her equipment at work and a coworker who could manage her work responsibilities in her absence.

Kerry, like Maureen, could choose when she pumped at work and had a theoretically flexible schedule to do so. However, she had little actual flexibility in her workload and its demands that sometimes required her immediate attention and, thus, the inability to pump. Kerry had also perceived that her HM supply was too low with her previous child, and worried that the same would occur with her second. This concern was in contrast to Avery, who felt confident in her HM supply with her first child and expected the same with her second, and Maureen, who had heard HM supply could be too low but did not predict a low supply for herself.

As a result of these differences, Maureen, Avery, and Kerry together illustrate the major findings from further analyses of our qualitative data. They have been selected from among 13 mothers in our total sample who worked outside the home. Among the 10 mothers not described here, three mothers had work contexts that each differed substantially from the larger sample and, thus, did not illustrate common considerations for pumping. One of these three worked in a

daycare center in the room next to her infant and, thus, could feed at the breast instead of pump at work. The second had intermittent temporary work that meant that she either pumped in bathrooms with a manual pump or waited to pump at home. The third worked in a fast food restaurant and could only pump in a public storage room in view of a security camera. An additional three mothers of the 10 that are not described here never successfully established feeding at the breast, and all of these three had stopped pumping and feeding any HM by the time they returned to work. The last four of the 10 working mothers not described here are similar to Maureen, Avery, and Kerry in their home and work contexts. Avery was chosen in lieu of one of these four mothers, who was also a teacher, because Avery illustrated a change in context between her first and second children and because the other mother had a private, lockable office, which is atypical for a teacher. Kerry and Maureen were chosen in lieu of the other three mothers who are not described here for two reasons. First, they illustrated a similar range of support at home and at work for pumping and bottle-feeding their HM as the mothers who are not described here. However, Kerry and Maureen illustrate phenomena not shown among the other three mothers—namely, a perception of low HM supply (Kerry) and difficulties using a pump (Maureen).

The findings described here fall under two general categories: the *considerations* that mothers must address to pump and bottle-feed and the *interpretations* that follow data that they collect from pumping and bottle-feeding HM. These considerations and interpretations are illustrated in detail in **Figure 6**. Considerations and interpretations were related to mothers' subsequent practices for pumping, feeding HM or formula from bottles, and feeding at the breast. Specifically, when mothers had considerations that were particularly numerous or cumbersome, they were more likely to reduce or stop pumping or to replace some or all bottled HM with



bottled formula. Many mothers cited the importance of support from their partners and employers in managing the tasks and considerations related to pumping and bottle-feeding their HM. Mothers who reduced or stopped pumping or replaced bottled HM with formula commonly cited interpretations that they were not meeting their infants' needs.

### **Maureen: A case study of the difficulties with pumps and the importance of partner support for the success of pumping and HM-feeding**

Maureen, a scientific researcher, was a first-time mother. As she also did not have exposure to HM-feeding through a family member or friend, she learned that HM was important from research she did during her pregnancy. Maureen felt unequipped to feed at the breast, and her shy nature meant she felt uncomfortable with public feeding at the breast. Further, as Maureen had not been at her job long enough to qualify for the full 6 weeks of paid leave, she used all her sick and vacation days to have one paid month of leave. She was only able to return to work part-time at home initially because of a supportive boss. She also felt taking more leave would endanger her long-term career prospects. Thus, Maureen expected to rely heavily on pumps and bottles to meet her HM-feeding goals. Her online research and a hospital class had left Maureen “overwhelmed” by the “second job” of pumping and bottle-feeding HM and worried about painful feeding at the breast or inadequate supply. Thus, Maureen hoped to feed HM until her infant was 6 months old, but expected it to be too challenging to continue beyond that point, and so anticipated using formula before then.

Maureen's views on HM and confidence in providing it improved substantially, permitting her to feed HM far longer than planned (> 1 year) and avoid using formula. This resulted primarily from having the support she needed to overcome obstacles to feeding at the

breast and pumping that she experienced, such as illness, latch difficulty, workplace constraints to pumping, and difficulty using her pump. In particular, proactive help from lactation consultants in her pediatrician's office was critical to establishing feeding at the breast:

Yeah, that first couple of weeks, they were like very good about, like they didn't like wait for me to ask for help. . . .they required me to show them that she had a good latch. Even though she was gaining weight well, like they could see my nipples were all torn up and I was not happy. And so they had me come in extra sessions just to like help me work on it. And that was very helpful. —Maureen, 5 months

In turn, this made Maureen comfortable in seeking help when she had difficulty with her pump after returning to work. Moreover, her baby's caregiver supported Maureen's desire to bottle-feed HM, and her husband supported her by helping to clean supplies and feed the baby at night.

Maureen was also successful despite continual trouble with pumping. Because of financial constraints, she began using a second-hand double-electric pump from an acquaintance. It was often nonfunctional, sometimes “pooping out” during a pumping session. In response, she bought—and carried back and forth to work—new tubes, replacement pump seals, and flanges in different sizes, which she changed out through the day to try to get enough HM out. To stimulate stronger let-down at work, she looked at photos of her baby and smelled worn baby clothes, and at home, pumped while feeding at the breast on the other side. However, inadequate milk output remained a problem. Maureen also expected that the pump would give out, and she felt like a “camel” carrying her heavy pump along with her usual bags. She needed to replace her pump, and knew a double-electric pump was critical to meet her high needs. However, only with a donation from family members was Maureen able to buy one and continue meeting her goals.

Maureen also faced challenges to pumping at work. Her office was visible to those standing outside it, and she broke fire code to hang blankets. Her research space was across the

building, requiring planning and disrupting work to have time to travel, pump and store HM, and clean supplies. She did appreciate, however, that her private office allowed her some autonomy:

I've seen like, you know, um, in places where like the pumping room is real busy, and you have to like schedule a time. And then you have to like plan everything around that and like rush over there. I just feel like it's really, at least it's really nice that whenever I want to pump I can.  
—Maureen, 7 months

However, as this was her only time in her office, Maureen had to combine lunch and office work with pumping. Further, as a private woman, she disliked washing supplies in common spaces:

I have to walk from my office to the bathroom like with my pumping stuff. And so I try to put it in a non-see-through bag. And I kind of run into like some of the administrators in the bathroom sometimes. And I mean I think, people know that I'm pumping, like it's not a shameful thing, but it's also just a little bit embarrassing. ... I just don't want people to see me, like washing it. Like I just feel like, I'm sure people know. I just don't want to make it so obvious. Probably just part of it is like my professional, you know, like I don't, I don't know. I want people to see me in like a professional way, and I just feel like that's a little weird.  
—Maureen, 4 months

Instead, she used cleaning wipes between pumping sessions. These challenges, and a belief that even her new pump was inferior to her infant at emptying her breasts, led her to worry about output:

Well, I just feel like a little bit like my self-worth is tied to my milk output. Like I, I feel like, 'Oh, if I'm not making enough milk, I'm not going to provide for my baby.' And so, but that adds to the stress, and then that makes it harder to get the milk out.  
—Maureen, 7 months

Moreover, although Maureen had a supportive caregiver—at a cost greater than her income, and again subsidized by her family—she had to prepare and label HM bottles nightly. Her science background led to concerns about the integrity and safety of her HM, and she used freezer thermometers and a bottle heater to retain the nutritional value of her HM.

Ultimately, Maureen attributed her success in the face of these obstacles, as well as an illness that hindered feeding at the breast, to the essential daily help and support of her husband

and financial help from her family members. Without this help, Maureen was emphatic that achieving her pumping and HM-feeding goals would have been impossible.

My wonderful husband has been trained [laughs] in washing the pumping parts, and that has made a huge difference. He, he'll even like sterilize them and stuff, sometimes. And then at night like there's always like a, the, the dirty bottles from daycare and then the, the fresh milk that I pump that day, that all needs to get, you know, dealt with, and so [husband] helps me with that, so that's good. [Otherwise] I probably would have given in and started, you know, doing like jars more, and pouches more and, and maybe formula. –Maureen, 7 months

### **Avery: A case study of the importance of workplace support for pumping success and the disconnection of mothers from their infants' needs**

Avery, a reserved but self-assured teacher with a 2-year-old daughter, joined the study when she was pregnant with a son. Avery was married, but her husband had not shared her desire for each pregnancy, encouraged her to feed HM only to avoid the cost of formula, and largely left her to assume the duties related to pumping and infant feeding. However, Avery was assisted in her goals—ideally, to feed HM until 1 year—by two key factors. First, her prior experience with feeding at the breast and pumping gave her confidence in her ability to do so again.

I'm a lot more confident this time around. Oh yeah. Because with her it was always like, people would say 'Oh, are you gonna breastfeed?' I'm like, 'I'm gonna try.' You know? That was always my... and this time I'm just gonna say 'Yeah.' You know, 'I am.' I did it with her, why won't I be able to do it with this one? ... [and I've learned that] right off the bat that it's okay, I think to use the breast pump, you know? ... So having that stuff ready, washed, ready to go. You know? Start storing up that milk, freezing that milk. –Avery, prenatal interview

Second, and importantly, Avery experienced fewer obstacles to pumping at work than she had with her first baby at the same job. Between her first and second pregnancies, her employer had made her workplace much more conducive to pumping. Instead of her prior bathroom pumping space, Avery was allowed to choose a small room to use. Her employer provided a high-quality double-electric pump, a rocking chair, and storage space supplies and HM. She could also machine-wash her pumping supplies in the adjacent kitchen. Avery describes this change:

[Before] I pumped in this nasty little bathroom off of the laundry room, and it was disgusting. Um, you know, I had to make sure I had a chair in there to sit down. I brought in a folding chair. And, and people didn't know what I was doing. Like, I, there was a couple, like my friends, like at school, you know, knew. But like, I don't think my supervisor knew, because I only did it when I *could* leave the room. ... I think I just did it on my lunch break. So I only pumped once a day. Um, 'cause I remember I went through my milk supply, my frozen supply, quick, because she had to use that and, plus what I had just pumped the one time. So, I was uncomfortable, first of all [laughs], for half the day. Um, and I had to bring my own—that pump—I had to bring it back and forth, you know. And I just had it in like a, you know, reusable grocery bag, and I was just so worried about, you know, bumping it against things. Is it gonna break? And, um. It's heavy. You know? And so it was a pain in the butt. I wouldn't have quit nursing 'cause I would've nursed in the, you know, still in the morning and in the night and everything. But she would've been on formula a lot sooner. ... [And now,] It's actually wonderful. Yeah. Everyone is so supportive. You know, my boss is so supportive. I think she realized that she has to be supportive. [laughs] ... I mean, not having to bring the pump back and forth, the pump there works wonderful. —Avery, 2.5 months

With these changes, Avery pumped three times as much as before, and only used a small amount of formula before her HM supply was established.

Avery found the transition from primarily feeding at the breast to regular bottle-feeding to be challenging. She believed that her baby would need a feeding routine, but felt uninformed about how to create one herself, and so she relied on her caregiver's experience and judgment. However, she often felt confused about how to feed her baby on the weekends. She wanted to be consistent, but felt disconnected from understanding his needs and disempowered to question her caregiver. She articulated this difference from the school year to summer and back:

I, being at home now for, you know, a month and a half or so I've been home, I am so, I feel like I am so much more in tune to him. Because then, it was like somebody else was making his schedule, and I'm asking them, 'When does my baby eat?' And I didn't like that, you know, but I had no control over it. Um, and I felt like he was eating, like he was having, he was eating when I didn't feel like he needed to be eating, like, um, that meal in the middle of the day when he was having his oatmeal and his fruit or whatever. Um, and so now that I've been home, I feel like I'm much more in tune to what he needs to eat, and I set the schedule now, so what I feel like is best for him and works best for us. —Avery, 9.5 months

Feeding on demand and reading her own baby's cues made Avery feel more calm, confident, and attuned as a mother. It also relieved what Avery saw as an unending set of tasks:

I have to do it, you know? Um, for lots of reasons. He needs his milk. I need to be comfortable. [laughs] Um, yeah, it's, it's a pain in the butt like having to make sure that I have the um, everything cleaned the night before so I have enough stuff to bring to work the next day. So every night I either have to, you know, throw everything in the dishwasher, run the dishwasher, make sure I'm doing the dishes. And you know you can't just have that night where you're like 'I don't feel like doing the dishes. Just leave them in the sink.' It's just something obviously I just have to do. –Avery, 2.5 months

Thus, relying primarily on feeding at the breast provided Avery with freedom and relief. When the next school year started, she continued feeding at the breast, and had enough stored HM to stop pumping and still avoid formula until and beyond 1 year.

### **Kerry: A case study of using pumps and bottles to perceive and respond to a gap in maternal HM supply and infant HM needs**

Kerry, an outgoing university staff member, was, like Avery, a second-time mother adding a son to a family that included a husband and young daughter. Kerry described her prior experiences with feeding at the breast and pumping as successful except for a falling supply that spurred hair loss and required formula-feeding. She anticipated the same problem with her second child, and planned to pump earlier and more often to improve her supply and delay the use of formula. She also anticipated her baby not accepting bottles, as her first hadn't, and consequently “bottle-trained” her baby with a nightly bottle as recommended by her pediatrician:

...the pediatrician said you really have to give him a bottle every day at this point so, otherwise he's going to lose interest in the bottle and then you're going to go to introduce the bottle around the time you have to go back to work, and he's not gonna want it. And we did see that happen, like when we started to try and reintroduce the bottle again, he was not for it. So I said to my husband, like 'We really have to, we really have to get on the schedule in the evening where he's getting a bottle in the evening, even if it's just a little something, you know, just for the purpose of having the bottle, not so much to eat.' –Kerry, 2 months

Kerry felt HM was important enough to take on as many tasks as needed to provide it. These tasks, in addition to those related to transporting, cleaning, and preparing supplies as

described by Maureen and Avery, also included steaming her pumped HM after each pumping session. Kerry did so out of a belief that the lipase levels in her HM were too high, turning it sour, because of her first baby's initial refusal of pumped HM, Kerry's perception that her pumped HM tasted bad, and a cousin's suggestion that this was due to high lipase. Consequently, for both children, Kerry steamed her pumped HM immediately after each pumping session, using an electric steamer at work and a stovetop pan at home. This time and effort were acceptable to Kerry as necessary costs of providing HM, as was her continual need to remind coworkers that she was unable to meet short-term deadlines and attend some meetings to pump.

However, over time, Kerry believed that her son's nutritional need for HM compared to formula and her ability to provide it via pumping were too low to justify these efforts. She, too, relied on her caregiver's reports of bottle intake and satisfaction. She trusted this judgment and, consequently, believed that the gap between her supply and her infant's needs was widening:

Well it wasn't so much me. It was that the sitter was saying 'He's really chugging his bottles, you know, he's really just downing them and acting like he could go for more.' And I said, 'Well then test it out with him!' You know, like, 'Instead of four, give him, give him, give him five. If he does five, you know, eventually, and he's acting hungry still, give him six.' So we went from three 4-ounce bottles, to four, I think it was, maybe it was eventually four 4-ounce, and then it was four—three—three or four 5-ounce, and now he's doing like, I think like three 6-ounce bottles. —Kerry, 6 months

This gap was stressful for Kerry when she felt primarily responsible for providing her baby's nutrition with HM but felt she needed formula to meet his needs. However, as he grew and relied more heavily on solids, and as Kerry "watched her supply drop" by seeing her pump output fall to "almost nothing," she finally "let work interfere" with pumping. Consequently, she dropped HM, adding whole milk to formula bottles between 10-11 months. Kerry continued feeding at the breast beyond 1 year, but felt it was for comfort and minimal nutrition. This shift to primarily

bottles and solids also reassured of how much her infant ate, rather than relying on him to “call the shots” at the breast, when she wasn’t sure she was producing enough:

The thought occurred to me, you know, he’s really not getting [at the breast] what he gets when he’s at, with the sitter, because he’s getting 6-ounce bottles [of formula and HM mixed]. And he’s, and I know that I’m pumping at best 3 ounces, pretty much, sometimes three and a half in a sitting. ...So if he’s just nursing off and on every couple hours, he’s not getting, you know, what he’s used to volumetrically from the sitter. So I, this last weekend, I made a point to pump at least once, um, and then, give him at least one feeding that way, so that I was, I knew that he was getting, like you know, a good six ounces. –Kerry, 6 months

## *Discussion*

We have described three mothers who had experiences with pumping and bottle-feeding their HM that were starkly different from their experiences feeding their infants at the breast. Further, their experiences differed substantially as a result of their home and work environments and their support systems for pumping and bottle-feeding their HM. The findings described here fell into three major themes. First, these mothers illustrated many tasks and considerations added by pumping and bottle-feeding HM compared to feeding only at the breast. These tasks and considerations were substantial for working mothers like Maureen, Avery, and Kerry and for mothers who were unable to feed their infants at the breast. Second, we showed that pumping and bottle-feeding HM provided data that mothers interpreted to inform their understanding of their ability to meet their infants’ needs. In turn, mothers’ tasks, considerations, and interpretations guided their subsequent practices for pumping and feeding their HM. Third, mothers reported a range in the support offered by their employers and partners, and that this support was important to managing the responsibilities of pumping and feeding their HM.

The three mothers described here illustrate tasks and considerations that were present for all mothers who pumped and bottle-fed their HM, regardless of how much they did. These tasks and considerations are illustrated in **Figure 6**. Mothers who did not use or were not satisfied with



second-hand pumps, such as Maureen, often bought new pumps. They weighed factors such as affordability, performance, and portability, which varied in priority and could conflict—e.g., affordable pumps with poor performance. All mothers had to learn how to pump effectively, and showed a range of effort and success in doing so. All mothers had to learn how to store their HM safely before it was fed to infants as well as how to bottle-feed it themselves or provide the means or instructions for others to do so.

These three mothers also show that tasks and considerations related to pumping and bottle-feeding were particularly numerous and cumbersome when mothers returned to work. This greater burden largely resulted from the fact that, in our sample of 20 women, most pumping was conducted at work and nearly all pumped HM was fed by other caregivers outside the home. Some mothers, like Maureen, had to assemble and label HM bottles for caregivers. Nearly all, like Avery and Kerry, cleaned and dried supplies themselves daily. Mothers who pumped at work had to remember all supplies to do so, including pumps, flanges, tubes, bottles, bags, pumping bras, wipes, and infant clothes or photos. They also had to negotiate several contextual factors related to their spaces, jobs, employers, and coworkers. For most mothers in our sample, the onset of regularly bottle-feeding HM mimicked formula-feeding in two ways. First, bottle-feeding HM required “instructions” for other caregivers on bottle size and frequency, either to minimize burdens on other caregivers or to compensate for mothers’ inability to interpret infants’ needs in the moment themselves. Second, before mothers transitioned to regularly relying on bottles and other caregivers, many also described a need to “bottle-train” their infants—i.e., to ensure that they would accept bottles when needed. However, this transition to regular bottle-feeding of HM differed from a transition to regular formula-feeding in two ways. First, mothers lacked the explicit instructions that come with infant formula and, thus, had to determine how to

create these instructions themselves. Second, a few mothers that were not described here also used pumps in an attempt to train their breasts to produce HM effectively at specific times in the day, either to facilitate pumping at certain times or to match pumping sessions to infants' bottle feeds to facilitate timely weekend feeds.

These reported tasks and considerations raise an important concern resulting from the fact that mothers bore nearly all this labor and thought themselves. Many mothers in our sample described cleaning and transporting equipment as a chore that consumed a lot of time and thought. For some mothers, including the three described here, their tasks and considerations caused stress. Kerry described stress resulting from the conflict between her pumping goals and her work responsibilities. Her job necessitated her presence at a number of meetings with colleagues, and Kerry regularly needed to voice and assert her need to pump and, thus, delay or miss these meetings. She felt her responsibilities at work were not optional and could not be delayed and, thus, she reduced and then stopped pumping. Avery and Maureen described stress related to the transportation of their pumps and pumping equipment; namely, the constant possibility that parts could be lost, forgotten, or damaged in transit. Any one such incident would prevent them from pumping, thus leaving their breasts engorged and a shortfall in their expected pumped HM output. These findings counter the suggestion that pumps and bottles reduce the burden of balancing HM-feeding and employment (13-16) (56).

In our sample, mothers who were regularly separated from their infants, including the three mothers described here, used information gleaned from pumps and bottles to understand their infants' needs and their own ability to meet them. Most mothers felt the data provided by pumping and bottle-feeding sessions was either unavailable or less accurate while feeding at the breast. Some, like Kerry, described appreciating the added knowledge, as it directly informed

their subsequent practices in a way that was either absent or lesser when they were feeding at the breast. Others, like Avery, felt relieved that they did not have to consider pump output or infant intake while feeding at the breast, even if they appreciated pump and bottle data when it was available. Regardless of whether mothers intentionally sought this information, or how they felt about having it, nearly all interpreted it. In turn, these interpretations guided mothers' future practices for pumping, bottle-feeding, and feeding at the breast.

Mothers gathered information from pumps firsthand, most commonly interpreting pump output to represent their supply. Moreover, mothers never interpreted falling pump output as part of a natural between-day fluctuation in their supply or their infants' intake or as a response to contextual stressors (129). Instead, they typically concluded that their supply was decreasing. For example, Maureen's pump output fell around the time that her responsibilities increased at work. She attributed this drop to a loss of her supply rather than any adverse impact of the stress of balancing work responsibilities with meeting her pumping goals. Less commonly, mothers interpreted pump output to represent their infants' intake at the breast or their needed intake from bottles. In contrast to pump data, mothers largely relied on other caregivers to provide bottle-feeding information. Avery and Kerry were particularly reliant on their caregivers to guide their own practices for bottle-feeding their infants. Many mothers and caregivers, including Avery and Kerry, perceived infants' needs as constant—i.e. a set number of ounces per bottle that only rose as infants grew. It was also common for caregivers, including those for Avery's and Kerry's infants, to interpret how much infants *would* consume from bottles as what infants *needed* to consume from bottles.

Mothers used this information to guide their intentions and practices for pumping, feeding at the breast, and bottle-feeding in the same general way: they directly compared pump

data, which represented their supply, to bottle data, which represented their infants' needs, to infer their ability to meet those needs. Some mothers, like Kerry, described attempts to get pump output to match infants' current demands, and used formula when they could not match demand. Others, like Maureen, described goals to exceed their infant's demands with their pump output such that they could store excess HM to be fed in the future. When pump output fell below bottle intake, many mothers added pumping or feeding at the breast sessions, if they were able and willing to do so, used supplements thought to increase HM supply, such as fenugreek and lactation-stimulating teas, or started or increased formula-feeding.

Mothers' use of pump and bottle data to guide their understandings of and practices for HM-feeding raises two key concerns. First, experimental data show that pump output varies widely by pump type (92, 130). Further, as we reported elsewhere (see Chapter 1), mothers often reported that pumps were less efficient than infants at emptying breasts, and that this gap was exacerbated by pump malfunction or difficulty pumping. Thus, it is plausible that interpretation of pump data may lead mothers to underestimate their HM supply. It is well known that mothers' perceptions of low or inadequate HM supply are key determinants of early cessation of any or exclusive HM-feeding (49, 50, 62). Thus, our findings suggest that pumping may increase risk of that perception and, thus, poorer HM-feeding outcomes.

Second, the availability and interpretation of these data may impose a psychological burden on mothers. Some, including Maureen and Avery, reported that, compared to feeding at the breast, the ability to see and measure pump output created or raised worries about the adequacy of their supply. Unmet pumping goals and, thus, unmet HM-feeding goals often resulted in mothers feeling disappointment, frustration, or personal failure. Those who responded by setting new pumping goals instead of stopping pumping had increased thoughts and worries.

Maureen, Avery, and Kerry also illustrate the important role of support from partners and employers in managing the tasks and considerations for pumping and bottle-feeding HM. Avery, with the support of her employer, was able to reduce and better manage her tasks and considerations for pumping at work. This directly led to more pumping and, thus, minimal reliance on formula. Maureen cited the daily help of her husband as the reason for her ability to surpass each new goal for HM-feeding. These findings show that mothers must be supported by those around them to be successful in pumping and bottle-feeding their HM. Employers can support mothers' pumping goals by providing private, easily-accessible spaces to pump, clean equipment, and store HM, space to store pumping supplies overnight, and, if possible, a hospital-grade pump to be shared by mothers who pump. Partners may provide important support for pumping and feeding HM by assisting with daily chores needed to pump and bottle-feed HM.

The data reported here have limitations. Primarily, these are findings that emerged during a qualitative study initially designed to investigate mothers' attitudes, perceptions, and practices for pumping and bottle-feeding HM. Thus, interviews did not include explicit questions about mothers' considerations for and thought processes about these practices and, thus, some considerations and thought processes were not an explicit focus of early interviews. However, these themes emerged throughout a diverse group of mothers without intentional investigation and, once apparent, were reflected in later interviews. This supports the validity of these data and the importance of investigating these themes further with national survey data.

This work also has a number of key strengths. The semistructured, longitudinal nature of this work uniquely allowed important, previously unconsidered themes to emerge. In fact, these findings reveal potential unintended consequences of the increasing substitution of pumping and

bottle-feeding for feeding at the breast. The findings of this work demand further investigation, as they may affect maternal and infant outcomes of public health importance.

### ***Conclusions***

Using these case studies, we showed here that the use of pumps and bottles in HM-feeding created tasks and considerations that were fewer in number or not needed with feeding at the breast. The burdens that mothers incurred as a result of these tasks and considerations raise independent concerns about their mental and physical well-being. Importantly, these findings also highlight that mothers attribute meaning to data from pump output and bottle intake data and perceived that they could train infants to consume and their breasts to produce HM on schedules. These perceptions may lead to suboptimal pumping and HM-feeding behaviors and, thus, health outcomes for mothers and infants. Our findings support a recent statement from pediatricians (78) urging caution about potential impacts of pumping and bottle-feeding HM.

Finally, our findings highlight the need for national policy that makes it possible for women to meet national goals for HM-feeding in ways that reduce both mothers' reliance on pumps and bottles to feed HM as well as the contextual obstacles to using pumps and bottles.

## CHAPTER 4

### PUMPING HUMAN MILK IN THE EARLY POSTPARTUM PERIOD: ITS ASSOCIATIONS WITH LONG-TERM PRACTICES FOR FEEDING HUMAN MILK AT THE BREAST, AT ALL, AND EXCLUSIVELY IN A LONGITUDINAL SURVEY COHORT

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## ***Abstract***

**Background.** Most American mothers who feed human milk (HM) now use HM expression (HME), with or without additional feeding at the breast (FAB) to provide HM to their infants. Although HME is recommended and promoted nationally, it is unknown whether HME impacts long-term infant feeding practices of public-health importance.

**Methods.** We analyzed data from 1,116 mothers in the Infant Feeding Practices Study II longitudinal survey cohort who both pumped their HM and fed HM to their infants between 1.5-4.5 months postpartum. We investigated the association of mothers' non-elective reasons for HME in relation to the duration of any HM-feeding, exclusive HM-feeding, and FAB. We used survival analyses to examine the association of frequency of mothers' HME during 1.5-4.5 months postpartum in relation to the duration of any HM-feeding, exclusive HM-feeding, and FAB.

**Results.** Mothers who cited any non-elective reasons for HME 1.5-4.5 months postpartum had shorter durations of HM-feeding compared to mothers who only pumped for elective reasons. There was a dose-response relation such that the greater the number of non-elective reasons the shorter the duration of each HM-feeding outcome. Compared to mothers with no non-elective HME reasons, mothers with 1 non-elective reason had greater average hazard of ceasing any HM-feeding (HR: 1.423, 95% CI 1.084 – 1.686), ceasing exclusive HM-feeding (HR: 1.397, 95% CI 1.081 – 1.806), and ceasing FAB (HR: 1.214, 95% CI 1.003 – 1.468). In adjusted analyses, considering both categorical and continuous variables, higher HME frequency was consistently associated with shorter HM-feeding durations. For example, compared to mothers in the lowest HME frequency group, mothers with the highest frequency of HME had a greater average hazard of ceasing any HM-feeding (HR: 1.401, 95% CI 1.095 – 1.793) and of ceasing



exclusive HM-feeding (HR: 1.279, 95% CI 1.047 – 1.562). Hazards of stopping FAB varied across the year, beginning with a strong association that reduced in magnitude over time. At 6 months postpartum, high frequency pumpers had greater than 6-fold higher hazard of stopping FAB than low-frequency pumpers (HR: 6.406, 95% CI 4.640 – 8.844).

**Conclusions.** Both maternal report of non-elective reasons for HME and a higher reported frequency of HME were associated with shorter durations of all three feeding outcomes. These findings suggest that the infants of mothers who have no choice but to pump—either due to work or difficulty with FAB—experience shorter duration of HM-feeding. An important as yet unanswered question is whether HME intensity affects the health, growth, and developmental outcomes for infants of mothers who rely on HME or pumping for reasons beyond their control.

## ***Introduction***

Until recently, it was possible but uncommon for mothers to empty their breasts of human milk (HM) solely by hand or with pumps (1-3). Now, most U.S. mothers who feed HM to their infants use pumps in place of some or all feeding at the breast (FAB). This shift resulted from the convergence of well-known employment-related constraints to FAB (4-7) and the availability of high-efficiency, double, electric, commercially available pumps (8, 9). HME is endorsed by the American Association for Pediatrics (10) and used by women to address the conflict between work and FAB (11, 12). Thus, human milk expression (HME) has been used as a means of meeting HM-feeding goals in the face of obstacles to FAB (11). National endorsements promote HME and bottle-feeding HM as equivalent to FAB for achieving long-term HM-feeding goals and optimal health outcomes for mother and infant (10, 13). However, little is known about the relationship between HME practices and HM-feeding outcomes.

Two recent, complementary longitudinal datasets now permit a better understanding of HME than ever before. First, a longitudinal survey, the Infant Feeding Practices Study II (14), provides the first quantitative data on HME from a national sample of ~3,000 mothers. In the IFPS II, among mothers feeding HM between 1.5-4.5 months, 85% had pumped their HM, some did so regularly or exclusively, and more than half began HME before 1 week postpartum (11). Second, our longitudinal qualitative investigation of 20 pumping mothers provides rich data on mothers' attitudes, perceptions, and determinants of and practices for HME (see Chapters 2-4).

Mothers pump for a diverse set of reasons that may impact how they use HME and, thus, feed HM. Mothers in our longitudinal ethnography described a wide range of reasons for pumping, including all nine potential reasons reported by IFPS II mothers (see Chapter 2), and other reasons, and provided key insights into ways the reasons for HME should be studied. The

reasons for HME given by mothers in our qualitative sample could be characterized by the degree to which mothers elected to pump and anticipated pumping. Whether or not the decision to pump was elective vs. non-elective explained, in part, the frequency of and strategy for HME. For example, mothers who pumped for non-elective reasons, such as returning to work or latch difficulty, pumped more frequently than mothers who did so only for elective reasons such as to allow other caregivers to bond with infants. The HME practices of mothers in the qualitative sample, in turn, related to the success they had in meeting long-term goals. Specifically, mothers who relied on pumps earlier and more frequently typically used formula or stopped feeding HM earlier than occasional pumpers. As mothers pump for many different reasons that impact their HME and feeding practices, these reasons must be considered when examining HME practices and their potential links to long-term feeding outcomes.

In theory, using HME when FAB is unavailable maintains or extends HM-feeding. However, the authors of a recent review of HME and HM-feeding duration found that HME was associated with longer HM-feeding duration only for some mothers (15). Moreover, the potential impact of HME on FAB practices is of particular interest. Some benefits to infants of FAB result from feeding at the breast *vs.* feeding HM from a bottle (16-19), and it is unknown if replacing FAB with HME impacts outcomes for mothers. It is critical to know if this substitution impacts the duration of HM-feeding and FAB. The data from the IFPS II provide the first opportunity to examine these relations.

To address these questions, we used data from the IFPS II to explore two research questions. First, we investigated the relation between mothers' reason(s) for HME and their HM-feeding durations. We hypothesized that mothers who had more non-elective reasons for HME would have shorter durations of any and exclusive HM-feeding and of FAB compared to mothers

with few or no non-elective reasons for HME. Second, we investigated whether and how the frequency of HME between 1.5-4.5 months was associated with long-term FAB and HM-feeding practices. We hypothesized that mothers who pumped more frequently between 1.5-4.5 months would have shorter durations of any and exclusive HM-feeding and of FAB compared to mothers who pumped less often.

## ***Methods***

*Study Participants.* We conducted a secondary analysis using data from the IFPS II dataset, which was collected by the U.S. Food and Drug Administration and the Centers for Disease Control and Prevention. Methods for the IFPS II survey cohort study are described in detail elsewhere (14). The sample of ~ 3,000 mothers from a national consumer opinion panel were surveyed once prenatally and 10 times across the first year postpartum. This cohort included mothers who were more likely to feed HM than national averages, and all infants were singletons born at term with birth weights > 2,500 g.

*Sample inclusion criteria.* We began by examining all mothers who fed HM and reported HME between 1.5-4.5 months postpartum. This interval reflects prior investigators' approaches (11), which reported HME practices separated into three mutually-exclusive postpartum ranges (1.5-4.5, 4.5-6.5, and 6.5-9.5 months postpartum). Briefly, mothers reported HME practices and reasons as well as their experiences with pumps on surveys that were completed at months 2, 5, and 7. However, as the timing of mothers' receipt and return of these surveys varied, surveys were regrouped by infant age at time of survey return in these three age ranges. Thus, we identified women that fed HM between 1.5-4.5 months (n = 1,696), then excluded all mothers who did not report HME practices in that interval, leaving 1,116 HM-feeding mothers who used HME between 1.5-4.5 months (**Figure 7**). As not all mothers fully characterized their HME

practices, we further excluded mothers who did not report HME frequency in the previous 2 weeks ( $n = 72$ ) leaving 1,044 mothers, or 93.5% of mothers who pumped, for inclusion in the main study analyses.

We examined the effect of HME practices on the duration of long-term HM-feeding outcomes in two ways: as both a categorical and a continuous predictor. Mothers' self-report of "regular" vs. "non-regular" HME was considered as a potential categorical HME variable. However, preliminary analyses showed a substantial misclassification between these self-reported data and whether mothers pumped above or below the median frequency of pumping (see Appendix D). Ultimately, we examined mothers' HME practices categorically in two ways: by dividing mothers at the median HME frequency and into HME frequency quartiles. We also modeled HME as a continuous predictor, calculating hazard ratios (HRs) for an increase of 10 HME episodes in the previous 2 weeks, or 1 HME episode per workday for two full work-weeks. Of the 1,044 mothers with available HME frequency data, 233 were excluded because they were missing model covariates, leaving 811 mothers for primary analyses.

*Primary exposure variable: Non-elective HME practices.* A quantitative score was calculated for each mother to indicate the extent to which she reported non-elective reasons for HME. In HME modules in the IFPS II surveys, mothers indicated their reasons for HME from a closed list of 9 options. Informed by our ethnographic data (see Chapter 2), we classified the 9 reasons as elective or non-elective (**Table 3**). The classification was based, in general, on whether mothers who pumped for a given reason did so without reference to current HM-feeding practices or challenges. Thus, *elective* reasons were *unrelated* to current HM-feeding practices or challenges, and *non-elective* reasons were *related* to current HM-feeding practices or challenges. One option, namely mother pumps "to provide HM for another caregiver to feed" may have

referred to pumping for both elective and non-elective reasons, therefore this was not included in score calculation; of the 8 remaining reasons, 5 were considered non-elective. Thus, mothers were assigned a score of 0-5 to indicate the number of non-elective reasons for HME they reported.

*Primary outcome variable: Feeding duration.* The primary study outcomes were the durations of any or exclusive HM feeding and duration of FAB; descriptive analyses present the median rather than the mean because a large percentage of mothers were right-censored at study end date (12 months post-partum). Reporting the median, rather than the mean, allows inclusion of these mothers and, thus, a more accurate representation of group practices. Mothers who were right-censored for feeding HM and FAB were arbitrarily assigned a duration value of 15 months for all calculations (this value exceeded all measured durations).

To create variables for the duration of feeding any or exclusive HM and of FAB, we first characterized feeding practices on each returned survey. Each month's survey included modules in which mothers estimated the feedings of HM, formula, and other milks in the prior week. Using these data we assigned each dyad a value of "yes," "no," or "missing/cannot determine" at each month for each of the following: HM-feeding, exclusive HM-feeding, FAB, and formula feeding (FF). Although one question explicitly asked about bottle-feeding HM, no question explicitly assessed FAB. Thus, other survey questions that referenced FAB were used to infer FAB status where possible (see Appendix E for details).

Two types of duration variables were created. *Inclusion* variables measured how long a behavior was present—i.e. duration of HM-feeding and FAB. For inclusion variables, we identified the last month that mothers reported that behavior, and durations were calculated as the midpoint between the infants' age at the time mothers returned that survey and the

subsequent survey. For example, for mothers who last reported HM-feeding on survey month 9, and reported no HM-feeding at month 10, the HM-feeding duration was the mean of her infant's age when she returned the survey for month 9 and month 10. *Exclusion* variables measured how long a behavior was absent—i.e. the duration of exclusive HM-feeding was the duration before formula or solids were introduced. In this instance, we identified the first month that mothers reported the behavior (for example, feeding formula), and the duration was calculated as the midpoint between the infants' age at the time mothers returned that survey and the previous survey. For example, for mothers who first reported feeding formula on survey month 5, the exclusive HM-feeding duration was the mean of her infant's age when she returned surveys from months 4 and 5. When mothers did not return the necessary adjacent survey, the most proximal adjacent survey was identified, and the duration was then calculated as the midpoint between that most proximal survey and the initially-identified survey. Durations are reported in weeks, and right-censored for survival analyses. For more detailed description of creation of duration variables see Appendix F.

*Other covariates.* We tested a range of variables as covariates in survival models. We identified potential covariates based on previous IFPS II analyses of HME practices and their determinants (11) and based on prior literature describing the predictors of HM-feeding practices (6, 16, 20-22). We used this literature and findings from our longitudinal ethnographic study of mothers who pumped and fed HM in the first year postpartum (see Chapters 2-4) to characterize the potential role of covariates in the relationship between HME and HM-feeding outcomes.

First, some potential covariates were identified as *antecedents*—i.e., they preceded and were found to be direct determinants of HME frequency—these antecedent variables were excluded from further models. The antecedent covariates included mothers' prior experience

feeding HM, infants' gestational age at birth, mode of delivery (vaginal, medicated, or cesarean delivery), the timing of onset of lactogenesis II, and mothers' prenatal reports of discomfort FAB in public. We also considered mothers' intentions for the duration of feeding any or exclusive HM as antecedent variables, as they were only measured prenatally in the IFPS II, and in this dataset, would only impact mothers' initial HME intensity. We also considered mothers' categorical HME reasons to be antecedent variables, as they necessarily precede and directly influence HME practices (23).

Second, we considered a number of socio-demographic potential *confounding factors*, including maternal age, race/ethnicity (white, black, Asian/Pacific Islander, Hispanic, or other), education (high school or less, some college, or college or more), income (<185%, 185-350%, or >350% the poverty income ratio), employment status between 1.5-4.5 months (yes or no), marital status (married, widowed, divorced, separated, or never married), postnatal participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (yes or no), body mass index category (normal weight, overweight, or obese), and national region of residence (Northeast, South, Midwest, and West).

Third, our ethnographic study findings suggested the association between HME practices and feeding durations may depend on mothers' experiences with pumps. Thus, we considered as *modifiers* the variables related to pumps: electric vs. non-electric pumps, new vs. used pumps, and mothers' reported satisfaction with their pumps (high vs. low-to-medium).

Finally, our ethnographic study findings also suggested that the association between HME frequency and human milk feeding duration may be impacted by, or act through, mothers' perceptions of their HM supply and their infants' needs. Thus, we considered infant bottle-emptying and mothers' perceptions of low HM supply as effect *modifiers* and *mediators*. Bottle-



emptying was directly measured on IFPS II surveys for months 3, 6, and 9; we used mothers' reports on the month 3 survey if their infants were between 1.5-4.5 months of age at the time they returned it. Perceptions of low HM supply were not measured by IFPS II surveys. We created a dichotomous variable for mothers' perceived low HM supply using mothers' reports of using HME to increase their HM supply or of introducing formula because they perceived their supply to be inadequate or their infants to be unsatisfied with HM alone (see Appendix X).

*Statistical Analyses.* For the first research question, we used survival analyses to investigate mothers' non-elective HME scores between 1.5-4.5 months as a predictor of the duration of any HM-feeding, FAB, and exclusive HM-feeding (3 separate models, one for each outcome). Because few mothers reported 3-5 non-elective reasons for HME in this interval, these mothers were combined into one group. Both unadjusted and adjusted models were tested. Adjusted models included all covariates in the models described below for the second research question except for employment-related variables, which were removed because of their direct impact on non-elective HME.

For the second research question, we used survival analyses to investigate HME frequency during 1.5-4.5 months as a predictor (parameterized as categorical and continuous) of the durations of any HM-feeding, FAB, and exclusive HM-feeding. To build survival models, we first sorted all potential covariates into four groups: socio-economic and socio-demographic, employment, FAB and lactation-related, and HME-related variables. We used log-rank tests of equality to identify potential categorical model covariates and Cox proportional hazards models to identify potential continuous model covariates from the list of potential confounders and modifiers. We visually compared between-category survival curves for each categorical variable to identify potential non-proportional effects on duration outcomes. Second, all covariates

identified in the first step that were considered to be potential confounders ( $\alpha = 0.20$ ) or would be considered as potential modifiers were included simultaneously in a Cox proportional hazards model to identify those that remained significant in the joint model ( $\alpha = 0.05$ ) or were considered important to the model and, thus ultimately included. At this step, we verified that each model contained covariates from each of the four groups of variables described in the first step.

Third, we tested potential two-way interactions between HME frequency and the three descriptive variables for pumps. Those that remained significant ( $\alpha = 0.20$ ) or substantially changed main effect parameters or significance were kept in models. Fourth, we considered models with significant confounders and modifiers both with and without the two potential mediators, bottle emptying and perceptions of low HM supply. Models with each mediator included were examined for their main effect parameters and significance in comparison to models without mediators. If effect estimates and significance were substantially reduced, mediators were left out of models. If a mediating effect was not seen, yet covariates were significantly associated with exposure and outcome, these covariates were tested for modifying or confounding effects and kept in models as appropriate. Fifth, we examined potential time-dependent effects between HME frequency and HM-feeding durations by including corresponding time-dependent covariates in the model. When time-dependent variables were significant in the model ( $\alpha = 0.05$ ), they were kept in the final model to account for these non-proportional effects and to obtain HRs at specific time points. All statistical analyses were conducted with SAS (Version 9.3, SAS Institute Inc., Cary, NC).

This research was declared “exempt” from human subjects research approval by the Cornell University Institutional Review Board because all data were de-identified.

## ***Results***

### **Reasons for HME and associated human milk-feeding practices**

The frequency of mothers' reported reasons for HME have been reported elsewhere (11). In our analyses, some of the most commonly cited reasons were associated with HM-feeding durations that were better or worse than those of the overall group.

Three reasons were linked with shorter HM-feeding durations. Mothers who pumped to feed their infants because they did not want to feed at the breast or because their infants could not feed at the breast had shorter durations of feeding any HM (median 35.2 *vs.* 40.9 weeks) and FAB (28.6 *vs.* 35.4 weeks) than the whole group. Mothers who pumped to increase their milk supply had shorter durations of feeding any HM (35.2 *vs.* 40.9 weeks) and of feeding HM exclusively (2.1 *vs.* 3.1 weeks) compared to the whole group. Mothers who pumped to maintain their supply when their infants could not nurse due to maternal work or infant illness also had a shorter duration of feeding HM exclusively (2.1 *vs.* 3.1 weeks).

In contrast, two reasons for HME were associated with longer HM-feeding durations. Mothers who pumped to have an emergency supply of milk had longer durations of feeding any HM (48.7 *vs.* 40.9 weeks), feeding HM exclusively (9.0 *vs.* 3.1 weeks) and of FAB (43.1 *vs.* 35.4 weeks) compared to the group as a whole. In addition, those who pumped to get milk for someone else to feed their infants had longer durations of FAB (40.4 *vs.* 35.4 weeks) and feeding HM exclusively (5.5 *vs.* 3.1 weeks) compared to the median in the full group.

Mothers who pumped for a greater number of non-elective reasons had shorter HM-feeding durations than mothers who pumped for fewer or no non-elective reasons (**Tables 4-6**). Notably, in unadjusted analyses, mothers who did not report any non-elective reason for pumping had substantially longer durations of exclusive HM-feeding than mothers who pumped

for non-elective reasons. The greatest difference in duration was between mothers with 0 vs. 1 non-elective reason (11.4 vs. 3.9 weeks); additional non-elective reasons were associated with relatively smaller differences in the duration of exclusive HM-feeding. In adjusted models, the number of non-elective reasons for HME was generally negatively associated with the duration of feeding any HM-feeding, exclusive HM-feeding, and FAB (**Table 7**). Mothers who pumped for 3-5 non-elective reasons had substantially higher average hazards of stopping any HM-feeding, stopping exclusive HM-feeding, and stopping FAB over the year than mothers who had 1 or 2 non-elective HME reasons.

### **Pumping practices and human milk-feeding outcomes**

*Any pumping vs. no pumping and feeding durations.* Mothers who pumped at all between 1.5-4.5 months stopped any HM-feeding about 8 weeks before mothers who did not pump stopped doing so (41.8 vs. 49.8 weeks) (**Table 8**). Mothers who pumped also stopped FAB about 12 weeks earlier than mothers who did not pump (37.0 vs. 49.1 weeks) (**Table 9**). Mothers who pumped were also less likely to be feeding HM or FAB at 6, 9, and 12 months, with a growing difference in proportions doing so over time.

*Pumping frequency and feeding durations.* In general, when mothers were divided into three groups—those who pumped less often than the group median, those in the third quartile, and those in the fourth quartile—shorter HM-feeding and FAB durations were observed with increasing frequency of HME (**Figures 8-10**). Among mothers who pumped, those who pumped at or below the group median HME frequency (6 times in the previous 2 weeks) fed their HM for about as long as mothers who did not pump, but stopped FAB ~ 3 weeks earlier. However, mothers who pumped more often than the group median stopped feeding HM ~ 14 weeks earlier

(35.6 vs. 49.8 weeks), and stopped FAB ~ 14 weeks earlier (34.1 vs. 49.1 weeks) compared to mothers who did not pump.

Considering mothers who pumped more often than the group median, mothers in the fourth quartile had the shortest HM-feeding and FAB durations. Mothers in the third quartile of HME frequency (7-14 times in the previous 2 weeks) stopped feeding their HM ~12 weeks earlier than mothers who did not pump (37.3 vs. 49.8 weeks), and mothers in the fourth quartile (> 14 times in the previous 2 weeks) stopped ~ 5 weeks earlier. Differences between these groups were larger for FAB durations, and mothers in the fourth quartile of HME stopped FAB ~18 weeks earlier than mothers who did not pump (22.8 vs. 49.1 weeks) and ~ 13 weeks earlier than mothers in the third quartile. Differences in exclusive HM-feeding outcomes between mothers who pumped above or below the median HME frequency and between HME frequency quartiles were either absent or comparatively smaller (**Table 10**).

### **Pumping frequency and associated continuation of human milk-feeding practices**

*Survival of HM-feeding.* In fully adjusted models using the categorical variable, mothers who pumped more frequently than the group median had a greater average hazard of stopping HM-feeding across the year (**Table 11**). Mothers who pumped with the greatest frequency had the highest hazard, but were not substantially different from mothers in the third quartile. In fully adjusted models using the continuous variable, an increase of 10 HME episodes over the previous 2 weeks was associated with a greater average hazard of cessation of stopping exclusive HM-feeding across the year.

*Survival of FAB.* In fully adjusted *categorical* models, HME frequency was significantly associated with shorter duration of FAB. We found a significant time-dependent effect of HME

frequency between 1.5-4.5 months and duration of FAB. That is, for frequent pumpers, the hazard of stopping FAB compared to less-frequent pumpers changed across the year. Specifically, the greatest HRs were seen in the earliest months (**Table 12**), although the difference between groups decreased and lost significance by 9 months postpartum. For example, at 3 months, mothers who pumped in the highest HME frequency quartile had a nearly 42-fold hazard of stopping FAB compared to mothers in the lowest quartile. However, at 9 months, the hazard of stopping FAB did not significantly differ between those most frequent pumpers and the least-frequent pumpers. In fully adjusted *continuous* models, an increase of 10 HME episodes over the previous 2 weeks was significantly associated with a greater average hazard of stopping FAB across the year. This association varied according to whether mothers reported indicators that suggested a perception of low HM supply. Specifically, the association between an increase of 10 HME episodes and shorter duration of FAB was more pronounced among mothers without a perception of low HM supply than in those with a perception of low HM supply.

*Survival of exclusive HM-feeding.* In fully adjusted *categorical* models, mothers who pumped more frequently than the median had a greater average hazard of ceasing exclusive HM-feeding across the year than mothers who pumped less often (**Table 13**). Mothers who pumped with the greatest frequency had the highest hazard, but were not markedly different from those in the third quartile. In fully adjusted *continuous* models, an increase of 10 HME episodes in the prior 2 weeks was associated with a greater average hazard of ceasing exclusive HM-feeding across the year. Again, mothers who pumped most frequently had the highest hazard.

## ***Discussion***

National recommendations, policies, and legislation support and promote HME as an equivalent means of supporting long-term HM-feeding goals when FAB is unavailable (24). In this epidemiologic investigation, however, our findings suggest that a greater frequency of HME is associated with shorter durations of feeding any HM, feeding exclusive HM, and FAB. Our findings further suggest that mothers who must rely on HME for non-elective reasons to a high degree may be particularly vulnerable to shorter HM-feeding durations.

In this sample, mothers who pumped for non-elective reasons—i.e., for reasons that were necessitated by difficulty with or unavailability of FAB—stopped feeding their HM exclusively and stopped feeding at the breast earlier than mothers who only pumped for elective reasons. The dose-response relationship that we observed suggested that, as the number non-elective reasons for HME increase, the duration of HM-feeding is shorter. This finding reflects our ethnographic work, reported elsewhere (see Chapter 2), in which mothers who pumped out of necessity early in infancy had shorter HM feeding durations than mothers who only pumped for elective reasons within their full control. These findings do not suggest that HME or pumps are, in and of themselves, problematic. Indeed, our ethnography highlighted positive attributes of the availability of HME. However, these findings suggest that HME is associated with shorter durations of HM-feeding when it is used because mothers have no choice—i.e., when FAB is unavailable or unsuccessful. Thus, these findings highlight the importance of efforts to make FAB an available choice and efforts to support FAB when mothers face breast feeding challenges. These efforts include policies that mandate paid maternity leave and/or workplace support for FAB, as well as targeted FAB support for mothers in the earliest postpartum weeks.

In this sample, greater HME frequency was associated with shorter duration of FAB in both categorical and continuous models. National recommendations are only framed in terms of feeding content—i.e., feed HM instead of formula, regardless of method. Thus, our findings are important because some of the benefits of HM-feeding are specifically linked with FAB. The potential effects of bottle-feeding HM in comparison to FAB has not been fully evaluated. For example, compared to bottle-feeding infant formula, FAB is more responsive to infant cues (19). Our ethnographic data, reported elsewhere (see Chapters 3 and 4), suggest this may also be true when comparing bottle-feeding HM to FAB. Moreover, FAB has been shown to be important for optimal development of cranio-facial muscles (25) and breathing patterns (26). Importantly, the significant time-dependence we found in our models for the duration of FAB suggests potentially important critical time windows where frequent HME should be avoided to prevent any adverse impacts on duration of FAB. Further work is needed to support this finding. A challenge to the direction of causality is that mothers who pump most frequently early in the post-partum period are likely to be those having difficulty FAB and, thus our findings also underscore the potential benefits of early support to successfully establish and maintain FAB.

Our findings that increased HME frequency was associated with a shorter duration of feeding HM raises concerns about infant health outcomes that drive national HM-feeding recommendations. Shorter duration of FAB is known to associate with increased risk of GI tract infections (27-29) and respiratory infections (30), hospitalization for respiratory infections (31), otitis media (32), and SIDS (33). Further research is needed to examine associations between mothers' HME practices and infant health outcomes to augment prior studies that focused only on FAB in relation to infant outcomes.



In our analyses, we found a significant statistical association between HME frequency and the duration of exclusive HM-feeding. However, poor exclusive HM-feeding practices in this sample limit the conclusions that can be drawn from these findings. Thus, the median duration of exclusive HM-feeding among all pumpers was ~ 3.4 weeks. When divided at the median HME frequency, mothers who pumped less frequently than the median exclusively fed HM significantly longer than frequent pumpers, but still only differed by ~1.1 weeks. Mothers in the highest HME frequency quartile only differed from the lowest quartile by ~ 1.6 weeks in exclusive HM-feeding duration. Thus, these differences may not be clinically significant. However, they do highlight that, even in a non-representative sample with generally better HM-feeding practices than the national average, exclusive HM-feeding practices are poor.

The analyses reported here have three key limitations. First, based on our ethnographic work, we wanted to examine the possibility that mothers' HME frequency is a mediator in an association between their reasons for HME and their long-term feeding outcomes. Our analyses show that some of the most commonly reported reasons for HME have associated HM-feeding durations that deviate from the group median. Thus, HME reasons may be the root driver of long-term HM-feeding outcomes. However, our exploratory analyses showed substantial overlap in indicated reasons, such that the impact of any given reason was impossible to ascertain. Using a non-elective HME reasons score allowed examination of this link, however, and showed a significant association between non-elective HME and poorer HM-feeding durations. Thus, the possibility that the association between HME frequency and these feeding durations may actually result from an association between HME reasons and feeding durations cannot be ruled out.

Second, the duration of HM-feeding and FAB were estimated for some mothers across intervals that ranged from 2—8 months because of missing data from unreturned surveys. This

estimation introduces some noise into our outcome data. However, we have no reason to believe the actual endpoint of HM-feeding and FAB in these intervals was not randomly distributed. Thus, we do not expect that the calculation of feeding duration using the midpoint of these intervals introduced bias into duration calculations. Last, our sample of mothers with complete data on all model covariates differed from those with missing data. Importantly, these mothers were more likely to pump at lower frequency, had more prior experience feeding HM, and intended to do so for longer, and were more likely to be working than mothers with missing data. These differences may have impacted the relationships examined here. Namely, we were less able to see how HME frequency related to long-term feeding practices among inexperienced mothers and those who pumped more frequently. However, this absence may have masked a still-more-pronounced association between HME and long-term feeding practices.

This analysis also has three key strengths. First, the longitudinal nature of the IFPS II permitted us to distinguish the impact of HME early in infancy and measure the progression of feeding behaviors over time. Second, although this sample was not representative of the U.S. population, it was large, diverse, and national, thus permitting generalization of these results to population practices and outcomes. Third, we have used previous ethnographic findings (see Chapters 2-4) to inform these analyses in key ways, namely in choosing potential model covariates, testing potential mediation and moderation in survival models, and creating and examining a variable representing mothers' non-elective reliance on HME. This mixed-methods design lends credence to the validity of our models, findings, and conclusions.

## ***Conclusions***

In this work, we found that mothers who used pumps with higher frequency in the early postpartum period had a significantly greater risk for shorter duration of HM-feeding practices than mothers who did not pump at all or pumped at low frequency. As a result, infants of mothers who pump with higher frequency in the early postpartum period may be at greater risk for the poorer health, growth, and development outcomes that follow suboptimal HM-feeding practices. Further, these quantitative findings support a conclusion from our ethnographic work, namely that it is not HME or pumps themselves that may hinder individual and national HM-feeding goals, but when mothers must pump for non-elective reasons—i.e., when FAB would be preferred.

Together, our findings signal the urgency of further investigation into the links among HME practices, their determinants, and subsequent long-term feeding and health, growth, and development outcomes for infants. This is critical because any risks created by HME may be disproportionately borne by infants of working mothers, who must rely heavily on pumps. Future research must clearly distinguish mothers' reasons for HME so that they may be effectively investigated for their links to practices and subsequent outcomes.

## CHAPTER 5

### CONCLUSIONS

This mixed-methods doctoral work provides a critical glimpse into the causes, practices, and potential consequences of the burgeoning national trend of pumping and bottle-feeding human milk. It does so with two complementary, longitudinal studies among diverse samples of women who pump and bottle-feed their human milk to their infants.

First, a longitudinal, qualitative investigation of mothers who pumped and bottle-fed their human milk, with or without additional feeding at the breast, provided rich insights into how mothers understand, feel about, and practice pumping and bottle-feeding human milk. These qualitative data showed that the incorporation of pumps and bottles into practices for feeding human milk has broad potential consequences for mother and infant. Namely, pumping and bottle-feeding human milk substantially affected mothers' daily lives. Namely, mothers' pumping and bottle-feeding practices necessitated a number of considerations and brought new means for mothers to understand their ability to meet their infants' needs. The availability of pumping as a means to provide human milk affected mothers' long-term intentions for feeding their milk and the strategies they used to work toward those goals. In addition, the use of bottles to feed infants was linked to both how and what infants were fed in ways that differed from how and what those infants were fed at the breast.

Second, secondary analysis of a longitudinal, national survey cohort, the Infant Feeding Practices Study II (IFPS II), provided the first quantitative data on how mothers' practices for pumping their milk in the early postpartum period may be associated with long-term practices for

feeding human milk. Our analyses showed that mothers who pumped with higher frequency when their infants were young had shorter durations of feeding their human milk exclusively or at all and of feeding their infants at the breast.

Together, the findings of these two studies illustrate a range of potential consequences to mothers and their infants of pumping and bottle-feeding human milk. All of these potential consequences are important for researchers, health professionals, and policymakers to consider in developing national recommendations and goals for feeding human milk. These chapters have been distinguished by type of data—qualitative or quantitative—and by mothers’ or infants’ perspectives. However, these data must be considered in tandem, as qualitative and quantitative data provide complementary insights. Moreover, mothers’ and infants’ perspectives must also be considered in tandem as they affect each other. Mothers’ pumping experiences affected the mothers themselves and also what and how their infants were fed. In turn, mothers’ and caregivers’ experiences feeding pumped milk affected mothers’ perceptions and pumping practices.

### ***Potential impacts of pumping and bottle-feeding human milk on infant outcomes***

With the qualitative data reported in Chapters 1, 2, and 3, we illustrate a number of ways in which mothers’ practices for pumping, transporting, storing, and feeding human milk may adversely affect both what and how infants are fed in the short- and long-term. With the quantitative data reported in Chapter 4, we show that mothers who pump their milk with higher frequency may feed human milk, feed exclusive human milk, and feed their infants at the breast for shorter durations than their counterparts who pump less frequently. Together, these findings suggest that infants who are bottle-fed human milk may be at higher risk for poor growth, health, and development outcomes than their counterparts who are fed at the breast.

We did not collect the biological samples that would permit us to draw conclusions about the content and integrity of pumped human milk compared to milk fed at the breast. Nonetheless, our qualitative data suggest three ways in which the content and integrity of pumped human milk as fed may differ from human milk fed from the breast. First, the macronutrient balance of pumped human milk as fed may be impacted by when mothers pump within the day as well as whether they pump before, during, after, or between feeding at the breast sessions. Second, the developmental appropriateness of pumped human milk as fed may depend on the length of time between when milk is pumped and when it is fed, which ranged from minutes to months in this sample. Third, the microbial safety of pumped human milk as fed may depend on whether mothers use secondhand pumps, how they clean those pumps, and how and where they store pumped milk until it is fed. However, no evidence-based guidelines exist for these practices. These findings are important because the wide range of practices for pumping, storing, preparing, and feeding human milk to infants raise questions about potential effects of these practices on infants' health, growth, and development compared to human milk fed at the breast. Biological data are urgently needed to characterize the content and integrity of pumped human milk as fed to infants—i.e., data that reflect these many practices—such that any potential consequences to infant outcomes may be explored.

These qualitative data also suggest that the manner in which human milk is fed from bottles—namely, less responsively to infants than feeding at the breast—may affect infants' growth and development outcomes. Specifically, when human milk was fed from bottles, the timing and size of feeds was more often determined by external cues, such as feeding schedules, pump output, and the size of previous bottle feeds. As infants' needs vary within and across days and weeks (113), these findings suggest a potential disconnect between infants' needs and

mothers' perceptions of those needs when bottle-feeding human milk compared to feeding it at the breast. This potential disconnect may be compounded by mothers' perceptions about the link between pump output and milk supply and about the nature of bottle-feeding vs. feeding at the breast. Moreover, regardless of the macronutrient balance in a given bottle, bottled human milk doesn't change in fat content across a feed as it would at the breast. Thus, infants fed human milk from bottles rather than at the breast may not have feeding times align with their hunger, and their feeding sessions lack a tangible end-of-feed signal. These changes to human milk-feeding may explain, in part, why infants bottle-fed human milk are less able to regulate their intake and gain weight faster than those fed at the breast (74-76).

Concerns raised by these qualitative data are magnified by our quantitative findings that mothers who pump with higher frequency early in infancy have poorer long-term feeding outcomes than their counterparts who pumped less. These data showed adverse impacts of higher pumping frequency on the duration of feeding any human milk, feeding human milk exclusively, and feeding at the breast. These findings are troubling in light of a large body of literature that supports longer duration of feeding human milk (3, 4, 6-9, 29), and doing so at the exclusion of feeding infant formula or early solids (4, 7, 9, 29), for optimal infant outcomes. Our findings raise further concerns in light of more recent data (72, 73, 134, 135) that show benefits to infant growth, health, and development that are specific to feeding at the breast compared to feeding human milk from bottles.

***Potential implications of pumping and bottle-feeding human milk for how mothers understand, experience, and benefit from HM-feeding***

The findings presented here paint a detailed picture of how pumping and bottle-feeding human milk may affect mothers in ways that do not inform in national recommendations, policies, and legislation. We show that, in addition to health outcomes for mothers, it is important to consider how pumping and bottle-feeding human milk may affect how mothers spend their time, thoughts, and finances, and how these practices may affect mothers' experiences at work and their psychological and emotional well-being.

All mothers who pumped had to make a range of decisions about which pumps to use and how to use them, as well as how to store, prepare, and feed their pumped milk. These considerations rose in number and complexity for mothers who returned to work while pumping their milk, as a number of contextual factors came into play. These considerations added substantial psychological or employment burdens for some working mothers. In addition, nearly all mothers in our qualitative sample, regardless of their working status or how much they relied on pumps, held perceptions about whether and how to interpret pump output and infant bottle consumption. These perceptions affected mothers' practices for pumping and feeding their milk insofar as they related to their perceptions of their ability to meet their infants' needs. Together, these findings suggest that, although pumping and bottle-feeding human milk are seen by many, including the women in our sample, as a means of easing the conflict between mothers' obligations to their infants and to their jobs, this may be far from the case.

Qualitative and quantitative data both suggest that mothers' pumping practices, particularly in the early postpartum period, may diminish the benefits conferred to mothers by feeding at the breast. Given the assertions of mothers in our qualitative sample that even the best



pumps are inferior to infants at emptying breasts, it may be that substituting pumping for feeding at the breast reduces demand for human milk from breasts. Our quantitative data support this possibility, as they suggest more frequent pumping in the early postpartum period may be associated with shorter durations of exclusive human milk-feeding and of feeding at the breast. In light of our qualitative findings, the shorter durations of HM-feeding among IFPS II mothers who pumped at high frequency may be explained, in part, by adverse effects of pumping on the milk supply of those women.

Together, these qualitative and quantitative findings suggest that, in comparison to feeding at the breast, pumping human milk may be linked to diminished maternal health benefits compared to those associated with feeding at the breast. These outcomes have yet to be investigated. Moreover, mothers' distress with and attitudes toward pumping as well suggest that those who pump their milk may not receive the same emotional benefits that mothers receive from feeding at the breast.

### ***The mixed-methods approach: strengths and limitations***

This mixed-methods approach had two key strengths. First, the two studies presented in these chapters were designed and conducted as a translational pair, with data from each study informing the design of the other. Namely, the design of qualitative interview guides was informed by other IFPS II investigators' reports of some pumping practices and their determinants (56) and by our preliminary analyses of IFPS II data. In turn, emerging data from mothers in our qualitative sample informed our analysis of the IFPS II in key ways. For example, the investigation of potential mediators and modifiers in the associations between pumping frequency and outcomes for feeding human milk, such as mothers' reported satisfaction with

their pumps and their infants' bottle-emptying behaviors, was directly informed by qualitative data. Moreover, both the qualitative and quantitative datasets were diverse and longitudinal, which facilitated the translation of data from one to design of the other in both directions.

Second, these two studies were also designed and conducted as a complementary pair, where each study's findings helped illuminate important findings from the other. Large, national quantitative datasets like the IFPS II influence public health policy because they provide the strongest evidence from observational study designs of potential large-scale consequences of health behaviors. These large datasets are limited, however, in their capacity to demonstrate how and why those potential consequences may occur or how they might be improved. In contrast, rich qualitative data like our ethnographic sample provide critical insights into how and why health behaviors are practiced, and elucidate what further questions must be answered. In turn, these rich qualitative data are limited by their inability to provide conclusions that are generalizable to larger populations. Thus, mixed-methods design is strengthened by the complementary nature of its two components. Findings from our qualitative work provided important insights into findings from quantitative analyses. For example, in our qualitative sample, mothers who pumped at higher frequency in the earliest postpartum days and weeks were those who were having trouble with latch or perceived that their milk supply was inadequate. Qualitative sample mothers who continued to pump at high frequency throughout the period examined in our quantitative sample—i.e., through 4.5 months—were those for whom feeding at the breast was prohibited regularly by working outside the home. Thus, these qualitative findings may explain, in part, why we observed a particularly strong association between pumping at high frequency between 1.5-4.5 months and shorter duration of feeding at the breast.

This mixed methods design also has a key limitation. Despite the complementary nature of these longitudinal studies and the related phenomena investigated in each, the capacity of each dataset to translate to design and analysis of the other was limited. Initial translation of early quantitative data to qualitative interview guides was hindered by the limitations of IFPS II surveys themselves. For example, initial qualitative interview guides for mothers' return to work were informed, in part, by three IFPS II surveys that included employment modules. However, qualitative mothers described a range of workplace factors and attitudinal characteristics that were not included in IFPS II modules but were important to their pumping intentions, practices, and successes. Thus, some important questions about employment contexts were not asked of early qualitative sample participants. In addition, the translation of qualitative findings to quantitative analyses was sometimes limited by the capacities of the IFPS II dataset. For example, qualitative mothers described distinct and differing attitudes toward feeding at the breast, toward pumping and bottle-feeding human milk, and toward formula-feeding that were strongly related to their intentions and practices. However, IFPS II surveys only indirectly asked about mothers' attitudes toward human milk vs. formula in a single question about whether mothers felt infants should be best fed by "breastfeeding," formula-feeding, or both. Thus, it was impossible to evaluate how mothers' attitudes might play a role in the relationship between their pumping practices and long-term feeding outcomes.

#### ***A host of unanswered research questions about pumping and bottle-feeding human milk***

Mothers in our qualitative study had a number of questions about how to safely store their milk and how to feed it to their infants so that their infants' needs were met. Mothers also made a number of assumptions when it came to pumping and bottle-feeding their milk. These

questions and assumptions signal that a lack of adequate information is available to mothers and suggest that their practices may be guided by misinformation and misconceptions. Moreover, the substantial variation in mothers' practices for storing, preparing, and feeding their milk indicates that the state of pumped human milk as fed also varies widely. Thus, four key research questions must urgently be addressed.

First, to understand and minimize risks of pathogenic contamination, the impact of mothers' practices for pumping, bottle-feeding, and handling pumped milk and pumping and bottle-feeding supplies on contamination of that milk must be investigated experimentally. It has been shown recently that pathogenic contamination of pumped human milk is widespread (80, 114), and exacerbated when mothers pump in non-medical *vs.* medical settings (79). Thus, evidence-based guidelines for best practices for cleaning supplies, storing pumped milk, and handling unfinished milk in bottles must be developed and made available to mothers.

Second, relationships between pumping and bottle-feeding human milk and infant health outcomes must be investigated further. In the IFPS II, infants who are fed human milk in a bottle have more episodes of coughing and wheezing than infants fed directly at the breast (120). In light of data showing pathogenic contamination of pumped human milk, outcomes for infant gastrointestinal and respiratory tract infections must be carefully investigated.

Third, the macronutrient content of pumped human milk as fed and the determinants of that content must be studied experimentally. Our qualitative findings and those from other investigators (77, 112) have suggested that this macronutrient content depends on when mothers pump in the day, when they pump relative to their feeding at the breast sessions, and the duration of pumping sessions. Further, the duration between pumping sessions and the feeding of that pumped milk to infants varied from minutes to months. Thus, the timing of when pumped milk is

fed relative to when that milk was pumped must be characterized carefully. These data are critical to ensure that pumped human milk fed to infants is both nutritionally adequate and developmentally appropriate.

Fourth, the relationships among pump output, mothers' human milk supply, and infants' intake at the breast must be investigated. Mothers' conceptions about these relationships were major drivers of how they understood their infants' needs and their ability to meet them and, in turn, their intentions and practices for pumping their milk and feeding their infants. Thus, data are needed that quantify these relationships such that clinicians may help mothers avoid making conclusions about their supply or their infants' needs that lead to suboptimal feeding practices.

### ***Implications for obstetric and pediatric clinical practices***

These findings show three key ways in which clinicians who serve pregnant and lactating mothers and their infants may assist them in optimizing their practices for feeding human milk.

First, qualitative data highlight that an important determinant of mothers' intentions and practices for pumping and feeding their milk is how they interpret the data available to them from pumps and bottles. Namely, mothers interpret pump output and bottle intake to understand their infants' needs and their ability to meet them. Clinicians may help deter mothers from suboptimal human milk-feeding practices by dispelling misconceptions about the equality of pump output and milk supply and about the speed of infant bottle consumption and infants' needs.

Second, clinicians may assist mothers by encouraging and supporting feeding at the breast. Mothers in our qualitative sample clearly stated that even the best pumps were inferior to infants at emptying breasts. In the IFPS II, mothers who pumped their milk more frequently had

dramatically shorter durations of feeding at the breast than those who pumped less frequently. This relationship was comparatively stronger than the association between pumping at high frequency and the duration of feeding human milk at all or exclusively by any method. As such, clinicians may help mothers maintain their supply and, thus, human milk-feeding by encouraging mothers to feed at the breast instead of pumping or bottle-feeding whenever possible. Clinicians may further support mothers and their human milk-feeding goals by offering on-site lactation consultants or by directing mothers to outside lactation consultants.

Third, clinicians may support mothers in meeting their goals for feeding human milk by advocating for mothers' timely receipt of high-quality pumps through their insurance policies. Mothers in our qualitative sample emphasized the importance of having the best double-electric pumps to produce enough milk in a manageable amount of time. Mothers who experienced early latch problems described the importance of having these pumps ready, and having had time to familiarize themselves with how to use them, by the time these latch problems occurred. However, the Affordable Care Act allows insurance providers to determine the type of pump provided, mothers' eligibility for hospital-grade pumps, and when mothers may receive pumps relative to delivery. Thus, clinicians may increase the likelihood that mothers receive high-quality pumps by requesting them from insurance providers.

Findings from our qualitative sample also showed that many mothers received inadequate or conflicting advice and assistance from health professionals. This reflects a theme reported recently by others who conducted focus groups among 56 mothers who pumped their milk due to supply concerns (137). The mothers in these focus groups reported frustration that the advice they received from health professionals was inconsistent or confusing or changed over time. In our sample, the adverse impacts of conflicting or confusing advice on mothers' stress level and

the success of her pumping and feeding practices were most pronounced in the earliest postpartum days. This was when mothers most struggled with successfully establishing feeding at the breast and/or pumping, and when helpful advice was most critical to establishing and maintaining the feeding of their milk to their infants. These findings highlight the importance of consistent, evidence-based guidelines not only for mothers, but also for the health professionals who help them.

### ***Implications for public policy***

Our findings suggest three clear avenues by which policy changes might optimize pumping and feeding human milk practices: by supporting feeding at the breast—most importantly, by providing adequate paid maternity leave to all mothers, and also by ensuring access to high-quality pumps and assistance in using them, and by supporting pumping in the workplace.

Two policy actions are critical to support feeding at the breast. First, and most importantly, the U.S. must implement federally-mandated paid maternity leave. Evidence from other developed countries clearly shows a strong link between available paid leave and better human milk-feeding practices (59). The Family and Medical Leave Act of 1993 (138) only provides up to 3 months of unpaid leave, and not to all women. This leaves women who work for small employers or who have been at their jobs for less than a year more vulnerable to any risks created by early, heavy reliance on pumps. Second, lactation consultants must be made available and affordable for all women who desire help with feeding at the breast. This help is particularly needed in the earliest days when establishing feeding at the breast is most critical.

Second, our qualitative findings also show that, for mothers who must or wish to rely regularly on pumps to provide human milk to their infants, access to high-quality pumps is paramount. The Affordable Care Act (24) mandates that insurance providers must provide pumps to mothers. However, insurance providers may choose the pump provided, and have no incentive to provide better pumps. Insurance providers may also determine whether mothers are eligible for hospital-grade pumps, whether a prescription is required to obtain a pump, and whether mothers may receive pumps before or after delivery. Moreover, mothers with insurance plans that were in place before the Affordable Care Act was signed do not benefit from the mandate to provide pumps at all. In light of our findings, the Affordable Care Act should be supplemented by a mandate that allows mothers the option of high-efficiency double-electric pumps and that provides them with these pumps before delivery.

Last, our qualitative data demonstrate that a range of workplace factors, which may be modified by policy changes, may affect the success and cleanliness of pumping in the workplace. Mothers' ability to pump as much as they wanted or needed to, the burdens that their pumping practices placed on their mental well-being, and their ability to meet their work responsibilities were all influenced by the intensity of their workloads and the flexibility of their schedules. The Affordable Care Act mandates that employers provide "reasonable" time to pump when mothers "need to," yet the meaning of these subjective terms is at the employers' discretion. Among mothers in our qualitative sample, some had the theoretical freedom to pump as they wished, but heavy workloads restricted their ability to do so. Others could only pump at set times, which didn't always align with when they needed to pump. The Affordable Care Act also mandates that employers provide "non-bathroom" space that is "shielded from the view of others" for mothers to pump. However, some mothers had to create privacy for themselves or pump in bathrooms.



These are also among likely strategies used by many mothers who pump in the workplace. Moreover, mothers' practices for cleaning pumping supplies and for storing pumped milk were influenced by their perceptions of the privacy of spaces available to do so and caused them use practices that would not be expected to be optimal for preserving the quality of human milk. There are no provisions in the Affordable Care Act that describe spaces available to mothers to clean supplies and store pumped milk. Together, these qualitative data show that pumping at work—and thus, human milk-feeding outcomes—must be supported by additional provisions that mandate private spaces to clean equipment, accessible spaces to pump, and flexibility in mothers' workloads and schedules such that they can pump as needed.

Taken together, this mixed-method doctoral work illustrates that the widespread adoption of pumping and bottle-feeding human milk has spurred fundamental changes to mothers' practices for providing human milk and feeding it to their infants. These changes include both what and how infants are fed in the short- and long-term as well as mothers' daily lives at home and at work and their understandings of their ability to meet their infants' needs. This work has raised a number of questions and concerns about pumping and bottle-feeding human milk that must be addressed with subsequent research, the creation of evidence-based guidelines for pumping, storing, preparing, and feeding human milk, and policy changes to better support pumping at work. Further, this work has also highlighted the importance of specifically supporting feeding at the breast for mothers who wish to do so for the long-term maintenance of human milk-feeding outcomes and for the well-being of mothers and infants. The findings from this doctoral work send a clear message to researchers, health professionals, and policymakers that pumping and bottle-feeding human milk are neither equivalent to feeding at the breast nor

adequate solutions for working mothers who cannot feed at the breast. Thus, the tasks ahead of the scientific, medical, and legislative communities are to provide support for feeding at the breast for mothers who wish to do so, and to provide adequate, consistent guidance and support for mothers who wish to pump and bottle-feed their milk to their infants.

## APPENDIX A

### QUALITATIVE METHODS

This appendix describes in detail the methods used to conduct the longitudinal ethnography described in Chapters 1-3. It also describes factors that impacted the success of recruitment and interviews.

#### ***Recruitment***

To reach our goal of a socio-demographically diverse sample, recruitment locations and strategies had to be similarly diverse. Both locations and strategies were adjusted over time, along with recruitment materials, to account for initial sample homogeneity. These methods and adjustments were successful and are described below.

#### **Recruitment Sites**

Initially-included locations were OB-GYN offices, Federal Supplemental Program for Women, Infants and Children (WIC) clinics, La Leche League (LLL) meetings, and weekly walk-in breastfeeding clinics at a parenting store. All available OB-GYN offices and WIC clinics in the included counties were contacted; all but one OB-GYN participated. LLL meetings and walk-in breastfeeding clinics were included and emphasized at the outset because of initial plans to include a cross-sectional sample of women interviewed only once at varying points postpartum. As such, many women recruited and interviewed at these locations were later dropped from the study.

Snowball and word-of-mouth were also included at the outset, and in-person recruitment and emails on university list-servs were later added to further increase capacity for diverse

recruitment and compensate for the necessity for good timing and prominent recruitment materials with recruitment in clinic locations.

### **Recruitment Materials**

Color posters were displayed in free-standing, clear plastic stands, each holding a stack of cards repeating study information and investigator contact information (**Photo 1**). These stands were left in OB-GYN and WIC clinic waiting areas. In all three counties, WIC staff members who specifically spoke to pregnant and breastfeeding women placed additional stands in their offices. In one OB-GYN office, staff volunteered to put an additional stand in a small, private room where women hear test results. At all locations, staff members were supplied with additional cards. These cards were also used for in-person recruitment, in which women were approached by the investigator in public places such as grocery stores and sidewalks. Recruitment materials were redesigned partway through recruitment as the early iteration (**Photo 2**) had very limited success. Consultation with a communications specialist yielded a more visible, compelling design. This change quickly proved effective at increasing recruitment when the investigator was not present.

### **Partnerships and Allies**

Partnerships were developed with OB-GYN offices and WIC clinics by contacting sites and setting up appointments to discuss study purpose, design, recruitment goals, and participants' burden with office managers and breastfeeding coordinators. Where possible, these meetings were conducted in person to facilitate building trust with these site gatekeepers, as their

help was essential for gaining optimal recruitment material placement and personal access to recruitment.

This early partnership-building facilitated ongoing recruitment, as many staff members became or provided important allies. For example, an office manager in an OB-GYN office were able to secure physicians' permission to include recruitment cards in folders of information already given to patients at appointment exit, increasing access to women who didn't see or pick up information in the waiting room, and intake staff at a high-volume WIC clinic informed the investigator of an intra-office color-coding system that provided easy, error-free identification of, and a non-offensive conversation opener for, pregnant women. WIC staff members also increased recruitment efficiency by informing the investigator of the day's prenatal appointments. At study end, small gifts were distributed to staff members at OB-GYN and WIC offices.

### **The Importance of In-Person Recruitment**

While recruitment benefited from a high number and variation of recruitment sites, recruitment was successful in large part due to in-person recruitment, regardless of location. This essentiality is likely due in part to the passive nature of recruitment with unmanned materials, but also might be explained by the private nature of the study topic. Mothers who would otherwise be interested in participating might balk at inviting a stranger to observe and ask questions about breastfeeding, and so recruitment in person may thus be critical overcoming that obstacle by establishing early trust and rapport. This may be particularly important among harder-to-reach demographics that differ from those of the investigator.

## ***Interviews***

Excluding women who were recruited for a discarded cross-sectional sample, study participants were recruited during pregnancy and interviewed during the third trimester, about two weeks postpartum, and at individual, important times of change thereafter. Interviews continued until either when both pumping and feeding breast milk stopped or one year postpartum, whichever came first. Interviews were semi-structured, and data collected included interview audio files, which were transcribed and coded, photos, and video.

Because mothers experienced unanticipated changes, such as a change in employment or childcare situation, and because the maximum number of mothers were recruited and none were lost, more interviews were conducted than anticipated; 107 instead of 80.

### **Interview Locations and Scheduling**

Most interviews were conducted in mothers' homes. Two participants requested prenatal visits elsewhere for convenience—one outside a coffee shop and outside an office building—and the investigator made this option clear to other mothers. Two participants offered to be interviewed in their workplaces—a school and an office building conducted in mothers' workplaces—so that the investigator could observe workplace pumping activities, and another participant was interviewed once in her mother's home for convenience.

After the prenatal interview, mothers were contacted roughly every week from three weeks before her due date. After the first postnatal interview at about two weeks postpartum, interviews were scheduled on an individual basis to follow important changes such as the start of pumping or using bottles or mothers' return to work. If these changes were anticipated, mothers were contacted by the method of their choice shortly afterward to inquire about that change (e.g.

“I know you were working on getting Baby to take a bottle. How is that going?”) and schedule the next interview. If no changes were planned, mothers were contacted every three to four weeks, and given a short list of yes-or-no questions (e.g. “Have you used a bottle to feed Baby anytime in the last month?”). If her answer indicated a change had occurred, mothers were then contacted. If mothers were unresponsive, contact efforts were repeated roughly every three days.

Wherever possible, interviews were scheduled according to mothers’ needs and preferences; childcare and work obligations provided the most constraints. If possible and comfortable with mothers, interviews were scheduled so as to include observation of pumping and/or feeding episodes. If disruption of interviews by other family members present had been problematic, the investigator attempted to schedule interviews at a minimally disruptive time, but always deferred to mothers’ preferences.

## **Interview Guides**

Interviews followed multiple semi-structured guides [see Appendix B] designed to correspond to progressive mother-infant dyadic stages: pregnancy, delivery and the initiation of feeding breast milk, mothers’ initiating pumping or returning to work, or infants’ introduction to bottles or solids. All interview guides included open-ended questions and prompts about breast milk pumping, storage, preparation, and feeding, as well as reasons for and attitudes and perceptions thereof, and mothers’ anticipations and plans.

Stage-specific interview guides included additional questions. For example, the first postnatal interview included questions about the delivery experience and the initiation of breast milk feeding, and the return to work interview included questions about workplace experiences. Moreover, due to the grounded theory nature of this investigation, as the study progressed and

new themes emerged, such as interpretation of the volume of milk obtained through pumping, corresponding questions were added.

Due to the highly variable nature of the dyad's first year, the order, number, and content of interviews correspondingly varied. As such, mothers were interviewed as few as three or as many as eight times. Some dyads omitted some stages (e.g., mothers who did not work in the first year) or may move through them concurrently (e.g. coinciding onset of pumping and return to work), and so interview guides were sometimes combined or omitted. Moreover, unforeseen circumstances such as a dramatic job change, the moving in of a mother-in-law, or the return or removal of other childcare duties often affected mothers' pumping and feeding behaviors significantly enough to warrant an interview.

Mothers who returned to work, particularly those who did so earlier or more intensely, those who had more major changes in pumping or feeding behaviors, and those who fed breast milk for a longer duration necessitated more interviews than those who didn't. Occasionally, follow-up questions were asked over email with prior permission from mothers.

Concurrently, in-depth observation was conducted to supplement textual data and to build upon interview questions. Observation enriched understanding and documentation of techniques for breast milk pumping, storage, and feeding that were not easily described or recalled by mothers, and of mothers' feeding styles and responsiveness to infant cues. These observations were recorded with field notes and with photos and video if mothers gave consent.

### **Interview Preparation**

Interviews were most successful when as much preparation as possible was done ahead of time. Interview guides were used to make field note templates that included spaces for time markers, observations, bulleted lists of topics, and shorthand to note mothers' answers. Before



each interview, previous field notes and audio from that mother were reviewed, and interview pre-notes were taken, designating a mother's progression, current status, and important questions to ask. The interview pre-notes and field templates collectively increased investigator capacity to listen to and observe detailed information at length more effectively by reducing necessity for recalling lists of questions and notes.

Given the often-chaotic lives of new mothers—particularly those with other childcare and work obligations—measures were taken to preemptively reduce interview disruption. Spare field note templates and extra gift cards were kept in the investigator's car, and spare batteries and a backup method of recording was always brought; all were used at least once. In addition, estimated travel time was increased by fifty percent to account for unexpected delays.

### **Building Rapport**

The longitudinal, in-home nature of this study provided many opportunities to build rapport. Many mothers mentioned enjoying participating, some expressing sadness that the study was over, explaining that this was a rare—and sometimes sole—opportunity to talk about their thoughts and feelings.

Building rapport began at the first contact, which was not necessarily the first interview. At this first contact, the investigator explained that she was not there to counsel on breastfeeding and did not have credentials to do so; that the study was designed in hopes mothers would help inform health professionals about their experiences and practices with feeding their babies. Moreover, mothers were told that, because they are offering the first information about pumping and feeding pumped milk, there are no wrong answers. This conversation, and talking each mother through confidentiality and photo and video consent, deliberately framed the control,

power, and informational value on the mother. If mothers consented to participate—and all did—they filled out an intake form with basic information, including how long they thought they might feed breast milk, when they planned to return to work, and family members.

Afterward, mothers were contacted by their chosen method, and while preference was given to meet during a feeding or pumping episodes, mothers dictated the day and time of the interview as much as possible so as to minimize disruption. During interviews, mothers were asked permission before turning on the recorder each time, and consent was asked each time photos or video were taken. At the end of each interview, mothers were allowed to examine and veto all photos and video. No photos or videos were vetoed in this study.

For interviews, care was taken with clothing choices to mimic mothers' manner of dress so as to not appear unprofessional and to facilitate mothers' comfort. For example, the interviewer wore casual clothing for earliest interviews postpartum, more professional dress when meeting mothers at work, and covered arms and legs when interviewing a woman of a faith that dictated she dress as such. The investigator remembered other family members and unrelated life events, and interacted with other children and pets when comfortable and appropriate. When other family members were present during an interview, the investigator took care to interact kindly with other family members, but keep the focus of the interview on the mother.

### ***Study End***

At each final interview, the investigator gave each study participant a card, a personal note, and a CD with digital copies of all photos that were taken through the study. Mothers were given the opportunity to add final thoughts and reflect on how they felt about their experiences throughout the year and their experiences participating in the study.

# Are you pregnant? Planning to breastfeed or use a breast pump?



A research group at **Cornell University** is looking for **expectant moms** to join a study about breastfeeding and using breast pumps.

We know feeding your baby your breast milk can be hard, especially for working moms and first-time moms.

**Your story is important,  
and we would love to hear it!**

We know new moms are busy, so don't worry – **we will come to you, and you'll get a GIFT CARD at each visit for your time.**

Participation is **confidential** and **voluntary**, and will not affect the benefits you receive through WIC.

**To find out more,  
with no obligations,  
TAKE A CARD  
and get in touch!**

Pregnant and planning to breastfeed or use a breast pump?  
**Your story is important, and we would love to hear it!**

Please get in touch with us to hear more about our study – no obligations! Participation is completely **confidential** and **voluntary**, and will not affect your WIC benefits.

We know new moms are busy, so **we will come to you**, and you'll get a **GIFT CARD** at each visit for your time.

Contact Julia anytime at:

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**Photo 1. Final recruitment posters and cards.** These materials were designed with important help from Stephanie Salato, who was the Communications Specialist in the Division of Nutritional Sciences at Cornell University. They proved successful at recruiting study participants when the investigator was not present.

# Pregnant? New mom?

*We'd love to talk to you.*

**Don't worry, we'll come to you. We know new moms are busy.**



A research group in the Division of Nutritional Sciences at Cornell is conducting a study about breastfeeding and pumping breast milk.

We're seeking expectant moms and new moms to interview about how you think and feel about breastfeeding and feeding your baby pumped breast milk, and how you put it into practice.

***Participation is  
confidential and voluntary,  
and will not affect the  
benefits you receive  
through WIC.***

To find out more,  
with no obligations,

**TAKE A CARD**

and get in touch  
with us!

A nutrition research group at Cornell is conducting a study about breastfeeding and pumping breast milk. We want to know how you think about, feel about, and practice breastfeeding and feeding your baby pumped breast milk.

**Participation is voluntary, always confidential, and will not affect your WIC benefits.**

**Asking for more information does not mean you have to participate!**

If you think you might be interested, you can contact me at:

Julia Felice

[jpf99@cornell.edu](mailto:jpf99@cornell.edu)

(617) 797-8618

**Photo 2. Initial posters and cards used for study recruitment.** These materials yielded little success in recruiting mothers when the investigator was not present to recruit mothers in person.

## APPENDIX B

### QUALITATIVE INTERVIEW GUIDES

This appendix includes multiple interview guides used to conduct the ethnographic investigation detailed in Chapters 1, 2, and 3. This investigation comprised a longitudinal series of semi-structured, in-depth interviews with women who pumped and fed their Human Milk (HM) from late pregnancy through 1 year *or* the cessation of feeding HM-feeding and Human Milk Expression (HME), whichever came first. Prenatal interviews were conducted in the third trimester. Subsequent, postpartum interviews were conducted at or around 2 weeks postpartum and shortly following important transition periods. These transitions included anticipated changes such as the start of HME or bottle-feeding, mothers' return to work, and the introduction to solids, as well as unanticipated changes in home and work contexts. Separate interview guides were created for each of these transitions, denoted with letters A—G, including different final interview guides for the cases where mothers had or had not continued HM-feeding through 1 year. Each interview guide included main themes for pumping and infant feeding as well as themes relevant to that transition.

## **Interview Guides**

- A. Prenatal interview**
- B. Early postpartum (~2 wk after delivery)**
- C. Start of HME and/or bottle-feeding**
- D. Mother's return to work**
- E. Introduction to complementary foods**
- F. Final interview: mother stopped pumping and feeding HM before 1 year**
- G. Final interview: mother was still pumping and feeding HM at 1 year**

## **General themes:**

- 1. Reasons for BF**
- 2. Reasons for FAB**
- 3. Attitudes and perceptions toward FAB**
- 4. Reasons for HME**
- 5. Attitudes and perceptions toward HME**
- 6. Attitudes and perceptions toward feeding EHM**
- 7. Perception of HME role in BF**
- 8. Plans and Intentions**
- 9. Concerns and Obstacles**
- 10. First Feeding Experiences**
- 11. FAB experiences, habits, and routines**
- 12. Obstacles or Difficulties with FAB**
- 13. HME experiences, habits, and routines**

- 14. Obstacles or Difficulties with HME**
- 15. Feeding EHM experiences, habits, and routines**
- 16. Obstacles or Difficulties with feeding EHM**
- 17. Signals, Responsiveness, and Feeding Styles FAB and HME**
- 18. Complementary Feeding**
- 19. Confidence and HM sufficiency**
- 20. Advice and information**
- 21. Support and resources**
- 22. Partner's attitudes, involvement, and relationship effects**
- 23. Employment Experiences**

Two considerations are of note. First, as interviews were semi-structured as per mothers' cues, responses, and situations, areas of interest were added to, expanded upon, or removed from portions of the interview. As such, the Interview Guide is meant to give an idea of the questions that were used rather than a rigorous demonstration of interviews. Moreover, mothers' individual situations and personal characteristics guided the omission or addition of questions as needed. Second, some mothers experienced more than one transition at the same time, and some experienced transitions that others didn't. Thus, interview guides were combined or skipped entirely as needed for that mother.

## **A. Prenatal interview (third trimester)**

*Warmup:* How has your pregnancy been going? How are you feeling?

*Probes* for general feelings about pregnancy, readiness for baby

A.23. Tell me about what you do.

*Probe* for feelings about job, relationship with employer, flexibility of hours, duration of paid/unpaid maternity leave

A.20. Have you had any questions about feeding or anything else during your pregnancy? What were some of these questions? Have you looked for answers? If so, who or where did you go to? If not, where might you start?

A.11-16. Talk to me about some of your prior experiences with breastfeeding and pumping.

*Probes:* A.3,5,20,21. How did you feel about how breastfeeding went? What were some things you learned during that experience that you might use this time around?

A.11,13,15. Were there any difficulties you ran into while breastfeeding, pumping, or feeding bottles?

A.20,21. Was there anyone or anything that helped you deal with those difficulties? Do you think that person/resource might be helpful again this time?

A.20. At this point in your pregnancy, what, if anything, do you know about feeding babies?

*(Wording will change based on parity)*

*Probe:* B.20. How did you come about this knowledge?

A.8. How do you envision feeding your baby when s/he is born?

A.1,2. What are some of your influences in coming to that vision of feeding your baby?



*(Or, if mentioned prior experience)* What were some of your influences in coming to that vision of feeding your older child? Are those influences the same this time around?

*Probe:* Is this vision something that has been forming during your pregnancy, or something you had thought about before?

*Probe:* A.2,3. Tell me about how feeding your baby directly at the breast came to be part of how you see yourself feeding your baby.

*Probe:* A.1,4. Are pumping and feeding your pumped milk part of your vision?

*Probe:* A.4,5. What influenced you to include pumping in your plans?

A.8. Do you have any particular goals you'd like to meet when it comes to feeding your baby?

A.21. *(Whether or not any particular goals)* What do you feel are/will be some of your best resources when it comes to feeding your baby the way you'd like to?

*Probe* A.21. for internal and external resources and sources of support.

A.9,19. Is there anything you see as an obstacle, or something that might make it more challenging to feed your baby the way you'd like to?

*Probe* A.19,21. Do you have any thoughts on how you might make this work?

A.19. How do you feel about your ability to meet these goals? Tell me more about why you feel that way.

A.7. When a woman says she is "breastfeeding," what do you picture?

*Probe:* A.7,8. How do you see pumping fitting into "breastfeeding" for you? For other women?

*Probe:* A.5,7. If you didn't have a need to pump (*based on her prior answers*), do you think you still would? Tell me about why you feel that way.

*Probe:* When you decided to "breastfeed" your baby, at what point did pumping come into the picture of how you saw "breastfeeding" happening?

A.3,5,6. If given a choice between feeding your baby at the breast or giving him/her a bottle of your pumped milk, do you think you have a personal preference?

*Probe* for factors influencing that preference, or if she says it depends, what factors might influence a situational preference.

*Probe* A.3,5,6. (*Wording will change based on parity*) Do you think your baby had/will have a preference?

A.8,23. (*If applicable*) When you go back to work, do you have any thoughts about how feeding your baby might change, if at all?

*Probes:* A.8,23. Do you plan on pumping while at work? Do you have a sense of where you might be able to pump and store your milk? Have you had any conversations with your boss or coworkers about your plans? Tell me about how that conversation went.

*Probe:* A.8,22. Do you envision any changes to your home routine once you return to work?

A.22. I see from what you wrote/said that you live with your husband/boyfriend/partner. How do you see yourselves balancing all your responsibilities as new parents?

*Probe:* A.21,22,23. How, if at all, do you see this balance shifting when you go back to work?

*Probe:* A.21,23. Have you talked with him about how you see yourself feeding your baby? Do you have any ideas about whether and how he might play a role in feeding your baby?

A.21. Looking forward to all the changes coming up, what do you see as your best resources? These could be other people, sources of advice or help, things about yourself, or anything.

A.9,19. Is there anything on your mind that you think might make moving through these changes a little more challenging? Or, are there any questions you have at this point?

*Closer:* Is there anything we haven't covered today that you feel is important to what you're going through right now? What you will be experiencing? Is there anything you think I should have asked?

## **B. Early postnatal interview**

*Warmup* chatting about new baby, etc.

*Opening sentence based on what little I know from contact between interviews about her delivery. I will typically know whether it was vaginal or Cesarean, delivery relative to due date, etc. Opening sentence may relate to her prenatal ideas about delivery, e.g. "I know your delivery didn't go quite how you thought it would. Tell me about what your experience was like."*

*Probes:* for

- feelings she had during this experience, e.g. confusion, fear, calm, confidence, sense of control
- use of pain medication was used, how this corresponded to her plan, how she felt in response
- B.21. people present before, during, and after delivery, e.g. partner, mother, family, friends
- immediate post-delivery events: where the baby went, how long until baby and mother were reunited, mother's autonomy during these events, health of mother and baby

B.10. Tell me about the very first time you tried to feed your baby.

*Probe:* B.20. Was someone there to help you do it? If so, who? Did they let you start on your own, or guide you on how to begin? Tell me about what they said or did.

*Probe:* B.10. How did you hold him/her, and was there any reason you chose that position?

*Probe:* B.10. Tell me about how latching went on your first try. Did you guide the baby, or did the baby latch him/herself? How did it feel? Do you think it worked? If not, was there help available?

*Probe:* B.3,10. Was there anything about this experience that was unexpected? Tell me about it.

*(General opener)* Describe for me what the remaining two/three days in the hospital were like.

*Probe:* B.21. Who was in the hospital with you? Was that who (all) you wanted there with you?

B.10. Did you feed your baby at the breast while you were staying at the hospital?

*Probe:* B.10,11. How did breastfeeding go? Did you have any problems or difficulties? Was there anything you were confused about, or any questions that you had? (*Probe* further for latch, positioning, discomfort, fatigue, timing, etc.)

B.13. Did you use a breast pump while you were in the hospital? Could you describe the very first time you used a breast pump?

*Probe:* B.4. Had you planned to pump while you were in the hospital? If so, why? If not, what was the influence to go ahead and start pumping?

*Probe:* B.13,20,21. Did anyone show or tell you how to use the pump? If so, could you describe what they said or did to help? If not, how did you go about using it for the first time?

*Probe:* B.13,14. Did you have any problems or difficulties? Was there anything you were confused about, or any questions that you had?

B.13. How did pumping go while you were in the hospital? Walk me through what would happen when you would use your pump.

*Probe:* B.13. How did you decide when it was time to pump?

*Probe:* B.13. How much breast milk might you get out when you pumped? What would happen with your pumped milk?

B.15. Did your baby get any bottles of your pumped milk or infant formula in the hospital? Who gave your baby that bottle(s), and what led to a bottle being introduced?

*Probe:* B.15. If you were the one that gave a bottle, could you describe what it was like?

*Probe:* B.15,16,20. Did you have any problems or questions giving the bottle? Did you get any advice or suggestions about giving a bottle, or how to do it?

B.20,21. While you were in the hospital, how did you feel about the doctors and nurses that were there? Did you feel comfortable talking to them or asking for help if you wanted it?

*Probe:* B.20,21. Did anyone in the hospital help you? Was help offered, or did you seek it out? If you sought it out, tell me about what you were looking for.

*Probe:* B.20,21. Describe what that conversation/interaction was like, and if/how they helped. How did you feel during this conversation? (*Probe* for whether help was warm or pushy, whether mother felt comfortable asking more questions, etc.)

B.17. While you were in the hospital, how did you know it was time to feed the baby?

*Probe, whether cue is infant-directed or time-directed:* B.20. How did you know that this was when to feed the baby?

*Probe:* B.3,6,7,11,12,15,16. (If mother was both feeding at the breast and bottle-feeding pumped milk or formula) How did you choose whether to feed your baby at the breast or use a bottle?

B.9,10,12,14,16,20,21. When you left the hospital, how were you feeling about how feeding was going?

*Probe:* Did you have any questions? Was there anything you were still confused about or having trouble with? Did you have any concerns about your transition home?

*Return home from hospital*

(General opener) Tell me about what your transition home was like.

*Support*

B.21. Was there anyone at home with you (other than your partner/husband)?

*Probe:* B.21. Was that who (all) you wanted there with you? or How did it feel having those people there? What was it about their presence that made you feel \_\_\_\_\_?

*Feeding at the breast*

B.10,11. Did you feed your baby at the breast when you got home? Describe what breastfeeding has been like for you two.

*Probe:* B.19. How do you feel like breastfeeding went in those first days? Was breastfeeding what you thought it was going to be like? Was there anything about this experience that was unexpected? Tell me about those. What happened when you came across these unexpected things?

*Probe:* B.10,11. When it's time to feed your baby, how do you decide things like which breast to start on or which position to use?

*Probe:* B.20. Did you use any of the advice or help you got in the hospital? How was that helpful, or not?

*Probe:* B.19,20. Was there anything about breastfeeding that was challenging or confusing? If so, was there anyone, or anything, you turned to for help? How did that go?

*Probe:* B.3,19. How are you feeling about breastfeeding right now? Do you feel like it's something that is working for you? Tell me about why you feel that way.

#### *Using a breast pump*

B.13. Have you pumped your breast milk since you got home?

*Probe:* B.4. What were some of your influences in pumping in the last couple weeks?

*Probe:* B.13,20,21. (*If no pumping in hospital*) Could you describe the very first time you used a breast pump? Did anyone show or tell you how to use the pump? If so, could you describe what they said or did to help? If not, how did you go about using it for the first time?

*Probe:* B.13,14. (*If pumped in hospital or not*) How has pumping been going since you've been home? Walk me through what happens when you use your pump. Is keeping track of your milk amount something that's important to you? What happens with your pumped milk?

*Probe:* B.13,14,20,21. Have you had any problems or difficulties with pumping? Was there anything you were confused about, or any questions that you had? If so, did you seek out help? Tell me about that.



*Probe:* B.5,19. How are you feeling about pumping right now? Do you feel like it's something that is working for you? Do you feel like pumping is helping you meet the goals you have for yourself?

*Feeding pumped milk or formula from bottles*

B.15. Has your baby gotten any bottles of your pumped milk or infant formula since you've gotten home? Talk to me about the time(s) that s/he got those bottle(s). (*Mothers will almost always state why here.*)

*Probe:* B.15,17. If you were the one that gave a bottle, could you describe what it was like? How did you know it was time to give a bottle? How did you decide how much should go in the bottle?

*Probe:* B.17. Describe how the bottle feed ended. *Probe to assess infant- vs. caregiver-directed.*

*Probe:* B.15,16,20. Did you have any problems or questions giving the bottle? Did you get any advice or suggestions about giving a bottle, or how to do it?

*Probe:* B.6,7. (*If mother is feeding formula*) How would you describe how formula fits in with breastfeeding for you? What are some of your influences in using formula while you breastfeed? *Probe* for how his perception may align with or differ from the role of EHM

*Responsiveness and cues, attitudes about FAB vs EHM*

B.17. Since you've been home, how have you known it was time to feed the baby?

*Probe, whether cue is infant-directed or time-directed:* B.20. How did you know to use this to decide when to feed the baby?

*Probe:* B.3,6,7,11,12,15,16. (If mother was both feeding at the breast and bottle-feeding pumped milk or formula) When your baby has mealtime, what influences whether it's at the breast or from a bottle?

*Probe:* B.20. When you are feeding your baby a bottle, how does a feeding usually end? What about when you're breastfeeding your baby, how does a feeding usually end?

*Alternatively,* How can you tell that a feeding is over?

*Plans and Intentions, Advice and information, Support and resources*

B.21,22. (If applicable) Has your husband/partner played a role in feeding your baby? Tell me about that.

B.21,22. (If applicable) Has feeding your baby changed how you or your husband/partner go about other tasks around the? Tell me about that.

B.8,9,11-16,20,21. Looking forward, how do you see the next few weeks going?

*Probe:* B.8. Are there any changes you see happening? Goals you'd like to work towards?

*Probe:* B.20,21. When it comes to moving through those changes, what do you see as your best resources? These could be other people, sources of advice or help, things about yourself, or anything.

*Probe:* B.9,19. Is there anything on your mind that you think might make moving through these changes a little more challenging? Or, are there any questions you have at this point?

*Probe:* B.20. Where do you think you might go to get help, if you need or want it?

*Closer:* Is there anything we haven't covered today that you feel is important to what you're going through right now? What you will be experiencing? Is there anything you think I should have asked?

### **C. Start of HME and/or bottle-feeding**

*(General opener)* So we set up this conversation today because you guys have been going through some changes! You told me you've started using your pump *or* You told me your baby has started getting pumped milk or formula from a bottle. How have things been going?

#### *Feeding at the breast*

C.11. You told me that you've still been feeding your baby at the breast since I was here last. Tell me about what that's been like for you two.

*Probe:* C.11. Walk me through what happens when you feed your baby at the breast.

*Further probes* for choosing sides, feeding from one or two and why, etc.

*Probe:* C.11. What has changed or stayed the same about breastfeeding since last time I was here?

*Probe:* C.19,20. Has there been anything about breastfeeding that's challenging or confusing? If so, was there anyone, or anything, you turned to for help? How did that go?

*Probe:* C.3,19. How are you feeling about breastfeeding right now? Do you feel like it's something that is working for you? Tell me about why you feel that way.

#### *Using a breast pump*

C.13. Walk me through what happens when you pump your milk.

*Probe:* C.4. What were your influences in starting to use your pump? Was this when you expected to start? Why or why not?

*Probe:* C.13. When do you use your pump? Why is this when you use your pump?

*Probe:* C.13,14,20,21. Have you had any problems or difficulties with pumping? Was there anything you were confused about, or any questions that you had? If so, did you seek out help? Tell me about that.

*Probe:* C.13,14. Is keeping track of your milk amount something that's important to you? What happens with your pumped milk?

*Probe:* C.5,19. How are you feeling about pumping right now? Do you feel like it's something that is working for you? Do you feel like pumping is helping you meet the goals you have for yourself?

*Feeding pumped milk or formula from bottles*

C.15. Has your baby gotten any bottles of your pumped milk or infant formula since you've gotten home? Talk to me about the time(s) that s/he got those bottle(s). (*Mothers will almost always state why here.*)

*Probe:* C.15,17. If you were the one that gave a bottle, could you describe what it was like? How did you know it was time to give a bottle? How did you decide how much should go in the bottle?

*Probe:* C.17. Describe how the bottle feed ended. *Probe to assess infant- vs. caregiver-directed.*

*Probe:* C.15,16,19,20. Did you have any problems or questions giving the bottle? Did you get any advice or suggestions about giving a bottle, or how to do it?

*Probe:* C.6,7. (*If mother is feeding formula*) How would you describe how formula fits in with breastfeeding for you? What are some of your influences in using formula while you breastfeed? *Probe* for how his perception may align with or differ from the role of EHM

*Responsiveness and cues, attitudes about FAB vs EHM*

C.17. Since I was here last, how have you known it was time to feed the baby?

*Probe, whether cue is infant-directed or time-directed:* C.20. How did you know to use this to decide when to feed the baby?

*Probe, whether cue is infant-directed or time-directed:* C.20. How did you know to use this to decide when to feed the baby? Is this the same or different from the last time I was here?

*Probe:* C.3,6,7,11,12,15,16. *(If mother was both feeding at the breast and bottle-feeding pumped milk or formula)* When your baby has mealtime, what influences whether it's at the breast or from a bottle?

*Probe:* C.20. When you are feeding your baby a bottle, how does a feeding usually end? What about when you're breastfeeding your baby, how does a feeding usually end?

*Alternatively,* How can you tell that a feeding is over?

*Plans and Intentions, Advice and information, Support and resources*

C.21,22. *(If applicable)* Has your husband/partner played a role in feeding your baby? Tell me about that.

C.21,22. *(If applicable)* Has feeding your baby changed how you or your husband/partner go about other tasks around the? Tell me about that.

C.8,9,11-16,20,21. Looking forward, how do you see the next few weeks going?

*Probe:* C.8. Are there any changes you see happening? Goals you'd like to work towards?

*Probe:* C.20,21. When it comes to moving through those changes, what do you see as your best resources? These could be other people, sources of advice or help, things about yourself, or anything.

*Probe:* C.9,19. Is there anything on your mind that you think might make moving through these changes a little more challenging? Or, are there any questions you have at this point?

*Probe:* C.20. Where do you think you might go to get help, if you need or want it?

*Closer:* Is there anything we haven't covered today that you feel is important to what you're going through right now? What you will be experiencing? Is there anything you think I should have asked?

## **D. Mother's return to work**

### *Employment Experiences*

D.23. Has your workday changed since you've gotten back, compared to how it was before you left for maternity leave?

D.23. Did you have any conversations with your boss/coworkers about what would happen when you got back to work? Tell me about those conversations.

*Probe:* D.23. How do you think your boss/coworkers feel about you pumping at work?

*Or* –about changes to your schedule since you've been back? Why do you think they feel this way?

### *Using a breast pump*

D.13,23. Have you been using your pump at work? Walk me through what happens when you pump your milk at work.

*Probe:* D.13,23. Where do you use your pump at work? How do you have access to it? Is this a space that was designated for you to pump before? How does this space feel for you? (*safety, privacy, cleanliness*)

*Probe:* D.13,23. When do you use your pump at work? Do you pump at the same time(s) every day? If not, what determines when you pump? If so, did you choose this schedule, or are these the times you had to use? Do you feel like you have enough time to pump as much/often as you want to?

*Probe:* D.13,23. What happens with your pumped milk while you're at work? *Probes* for what it is stored in, where it is stored, privacy, etc.



*Probe:* D.13,23. How do you prepare to pump while you're at work—what do you take back and forth each day, how do you care for your equipment, etc.?

D.13. Have you been pumping while you're at home? Tell me about how that happens.

*Probe:* D.4. What are your influences in using the pump at home as well as at work?

*Probe:* D.13. When do you use your pump at home? Why is this when you use your pump?

D.13,14. What happens with your pumped milk?

D.13,14. Is keeping track of your milk amount something that's important to you? Why is knowing this important to you? What do you learn from keeping track of that?

D.13,14,20,21. Have you had any problems or difficulties with pumping? Was there anything you were confused about, or any questions that you had? If so, did you seek out help? Tell me about that.

D.5,19. How are you feeling about pumping right now? Do you feel like it's something that is working for you? Do you feel like pumping is helping you meet the goals you have for yourself?

### *Feeding at the breast*

D.11. You told me that you've still been feeding your baby at the breast since I was here last. Has that only been when you're at home? Tell me about what that's been like for you two.

D.11. Walk me through what happens when you feed your baby at the breast. *Further probes* for choosing sides, feeding from one or two and why, etc.

*Probe:* D.11. What has changed or stayed the same about breastfeeding since last time I was here?

*Probe:* D.19,20. Has there been anything about breastfeeding that's challenging or confusing? If so, was there anyone, or anything, you turned to for help? How did that go?

*Probe:* D.3,19. How are you feeling about breastfeeding right now? Do you feel like it's something that is working for you? Tell me about why you feel that way.

*Feeding pumped milk or formula from bottles*

D.15. Has your baby gotten any bottles of your pumped milk or infant formula since I was here last? Talk to me about the time(s) that s/he got those bottle(s). (*Mothers will almost always state why here.*)

*Probe:* D.15,17. If you were the one that gave a bottle, could you describe what it was like? How did you know it was time to give a bottle? How did you decide how much should go in the bottle?

*Probe:* D.17. Describe how the bottle feed ended. *Probe to assess infant- vs. caregiver-directed.*

*Probe:* D.15,16,19,20. Did you have any problems or questions giving the bottle? Did you get any advice or suggestions about giving a bottle, or how to do it?

*Probe:* D.15,17. Does your baby get bottles while you're at work? *Probe* for however much knowledge a mother has about her baby's meals when she is not around.

*Probe:* D.6,7. (*If mother is feeding formula*) How would you describe how formula fits in with breastfeeding for you? What are some of your influences in using formula while you breastfeed? *Probe* for how his perception may align with or differ from the role of EHM

*Responsiveness and cues, attitudes about FAB vs EHM*

D.17. Since I was here last, how have you known it was time to feed the baby when you're with him/her?

*Probe, whether cue is infant-directed or time-directed:* D.20. How did you know to use this to decide when to feed the baby?

*Probe, whether cue is infant-directed or time-directed:* D.20. How did you know to use this to decide when to feed the baby? Is this the same or different from the last time I was here?

*Probe:* D.3,6,7,11,12,15,16. *(If mother was both feeding at the breast and bottle-feeding pumped milk or formula)* When your baby has mealtime, what influences whether it's at the breast or from a bottle?

*Probe:* D.20. When you are feeding your baby a bottle, how does a feeding usually end? What about when you're breastfeeding your baby, how does a feeding usually end?

*Alternatively,* How can you tell that a feeding is over?

D.11,13,15. Has going back to work changed how you feed your baby at home? *And/or* Have your baby's eating routines changed since you've gone back to work?

*Plans and Intentions, Advice and information, Support and resources*

D.21,22. *(If applicable)* Has your husband/partner played a role in feeding your baby? Tell me about that.

D.21,22. *(If applicable)* Has feeding your baby changed how you or your husband/partner go about other tasks around the? Tell me about that.

D.8,9,11-16,20,21. Looking forward, how do you see the next few weeks going?

*Probe:* D.8. Are there any changes you see happening? Goals you'd like to work towards?

*Probe:* D.20,21. When it comes to moving through those changes, what do you see as your best resources? These could be other people, sources of advice or help, things about yourself, or anything.

*Probe:* D.9,19. Is there anything on your mind that you think might make moving through these changes a little more challenging? Or, are there any questions you have at this point?

*Probe:* D.20. Where do you think you might go to get help, if you need or want it?

*Closer:* Is there anything we haven't covered today that you feel is important to what you're going through right now? What you will be experiencing? Is there anything you think I should have asked?

## **E. Introduction to complementary foods**

*(General opener)* We set up this conversation today because you've been going through some changes! I know you guys have started solids now. How has that been going?

E.18. Tell me about the very first time you tried solids with your baby.

E.17,18,20. What were some of your influences in deciding that it was the right time to start? *Probe* for infant- vs. caregiver directed, sources of information, planned vs. unplanned start

E.15. Do you ever use your pumped milk when feeding your baby solids?

*Probe* for use before, during, or after meal

*Probe:* E.17,18,20. Tell me about when you started thinking about using your pumped milk when feeding your baby solids.

## *Employment Experiences*

E.23. How has work been going lately? Has your workday changed at all since last time I was here?

E.23. How do you think your boss/coworkers feel about you pumping at work? *Or* –about changes to your schedule since you've been back? Why do you think they feel this way?

## *Using a breast pump*

E.13,23. Have you been using your pump at work? How has that been working for you?

E.13,23. Walk me through what happens when you pump your milk at work.

*Probe:* E.13,23. Has your pumping routine changed at all since last time I was here? Tell me about those changes. What brought them about?

E.13. Have you been pumping while you're at home? Tell me about how that happens.

*Probe:* E.4. What are your influences in using the pump at home as well as at work?

*Probe:* E.13. When do you use your pump at home? Why is this when you use your pump?

E.13,14. Is keeping track of your milk amount something that's important to you? Tell me about why you feel that way. What do you learn from keeping track of that?

E.13,14. What happens with your pumped milk?

E.13,14,20,21. Have you had any problems or difficulties with pumping? Was there anything you were confused about, or any questions that you had? If so, did you seek out help? Tell me about that.

E.5,19. How are you feeling about pumping right now? Do you feel like it's something that is working for you?

E.5,6,7,19. Do you feel like pumping is helping you meet the goals you have for yourself? How? How would you describe how formula fits in with breastfeeding for you?

### *Feeding at the breast*

E.11. You told me that you've still been feeding your baby at the breast since I was here last. Has that only been when you're at home? Tell me about what that's been like for you two.

E.11. Walk me through what happens when you feed your baby at the breast. *Further probes* for choosing sides, feeding from one or two and why, etc.

*Probe:* E.11. What has changed or stayed the same about breastfeeding since last time I was here?

*Probe:* E.19,20. Has there been anything about breastfeeding that's challenging or confusing? If so, was there anyone, or anything, you turned to for help? How did that go?

*Probe:* E.3,19. How are you feeling about breastfeeding right now? Do you feel like it's something that is working for you? Tell me about why you feel that way.

*Feeding pumped milk or formula from bottles*

E.15. Has your baby gotten any bottles of your pumped milk or infant formula since I was here last? Talk to me about the time(s) that s/he got those bottle(s). (*Mothers will almost always state why here.*)

*Probe:* E.15,17. If you were the one that gave a bottle, could you describe what it was like? How did you know it was time to give a bottle? How did you decide how much should go in the bottle?

*Probe:* E.17. Describe how the bottle feed ended. *Probe to assess infant- vs. caregiver-directed.*

*Probe:* E.15,16,19,20. Did you have any problems or questions giving the bottle? Did you get any advice or suggestions about giving a bottle, or how to do it?

*Probe:* E.15,17. Does your baby get bottles while you're at work? *Probe* for however much knowledge a mother has about her baby's meals when she is not around.

*Probe:* E.6,7. (*If mother is feeding formula*) How would you describe how pumped milk fits in with how you feed your baby right now?

*Probe:* E.6,7. (*If mother is feeding formula*) How would you describe how formula fits in with breastfeeding for you? What are some of your influences in using formula while you breastfeed? *Probe* for how his perception may align with or differ from the role of EHM

*Responsiveness and cues, attitudes about FAB vs EHM*

E.17. Since I was here last, how have you known it was time to feed the baby when you're with him/her?

*Probe, whether cue is infant-directed or time-directed:* E.20. How did you know to use this to decide when to feed the baby?

*Probe, whether cue is infant-directed or time-directed:* E.20. How did you know to use this to decide when to feed the baby? Is this the same or different from the last time I was here?

*Probe:* E.3,6,7,11,12,15,16. *(If mother was both feeding at the breast and bottle-feeding pumped milk or formula)* When your baby has mealtime, what influences whether it's at the breast or from a bottle?

*Probe:* E.20. When you are feeding your baby a bottle, how does a feeding usually end? What about when you're breastfeeding your baby, how does a feeding usually end?

*Alternatively,* How can you tell that a feeding is over?

*Plans and Intentions, Advice and information, Support and resources*

E.21,22. *(If applicable)* Has your husband/partner played a role in feeding your baby? Tell me about that.

E.21,22. *(If applicable)* Has feeding your baby changed how you or your husband/partner go about other tasks around the? Tell me about that.

E.8,9,11-16,20,21. Looking forward, how do you see the next few weeks going?



*Probe:* E.8. Are there any changes you see happening? Goals you'd like to work towards?

*Probe:* E.20,21. When it comes to moving through those changes, what do you see as your best resources? These could be other people, sources of advice or help, things about yourself, or anything.

*Probe:* E.9,19. Is there anything on your mind that you think might make moving through these changes a little more challenging? Or, are there any questions you have at this point?

*Probe:* E.20. Where do you think you might go to get help, if you need or want it?

*Closer:* Is there anything we haven't covered today that you feel is important to what you're going through right now? What you will be experiencing? Is there anything you think I should have asked?

## **F1. End of HM-feeding and HME before 1 year**

*(General opener)* We set up this conversation today because guys have made the transition away from breastfeeding and pumping. How has everything been going?

### *Feeding at the breast*

F.2,3. Tell me about the time leading up to when you stopped feeding your baby at the breast.

*Probe:* F.3,12. How was breastfeeding going for you around then? Was breastfeeding working for you? If not, what wasn't going the way you'd hoped?

*Probe:* F.2,3. Were you working towards weaning in this time? If so, what were your influences in deciding it was time to wean?

### *Using a breast pump*

F.13,23. Tell me about the time leading up to when you stopped using your pump.

*Probe:* F.13,14,23. How was pumping going for you around then? Do you feel like it was working for you? If not, what wasn't going the way you'd hoped?

*Probe:* F.13,23. Were you using your pump at work? Had that changed since last time I was here? Tell me about those changes.

*Probe:* F.13,23. Were you using your pump at home? Had that changed since last time I was here? Tell me about those changes.

*Probe:* F.13,14. Was keeping track of your milk amount something that's important to you? Tell me about why you felt that way. What did you learn from keeping track of that?

*Probe:* F.13,14. Were you working towards moving away from pumping in this time? If so, what were your influences in deciding it was time to stop pumping?

*Feeding pumped milk or formula from bottles, Responsiveness and cues*

F.15. Tell me about how your baby eats now. How do you guys move through a day?

*Probe:* F.15,17. Do you feed your baby from a bottle? Can you walk me through how that happens?

*Probe:* F.15,17. How do you know when it's time to give a bottle? How did you decide how much should go in the bottle?

*Probe:* F.17. How does a feeding usually end? *Probe to assess infant- vs. caregiver-directed.*

*Probe:* F.15,17. Does anyone else feed your baby bottles? What do you know about how that happens? *Probe* for schedules, routines, infant- vs. caregiver-directed

*Probe:* F.7,15,16. Is your baby getting any of your pumped milk at this point? Tell me how your pumped milk fits in with how you feed your baby.

*Probe:* F.6,7. (If mother is feeding formula) How would you describe how formula fits in with breastfeeding for you? What are some of your influences in using formula while you breastfeed? *Probe* for how his perception may align with or differ from the role of EHM

*Attitudes and perceptions, Confidence and HM sufficiency*

F.3,5,6,11-16,19. Looking back from before you had your baby to now, what were some of the things that you anticipated about feeding your baby that you ended up experiencing?

F.3,5,6,11-16,19. Was there anything about feeding your baby that wasn't what you anticipated?

F.3,11,12. How do you feel about your experiences feeding your baby at the breast?

F.5,6,13-16. How do you feel about your experiences using a pump? Feeding your pumped milk?

F.5,7. Looking back, how do you think pumping fit into breastfeeding for you? *Probes* for degree of involvement, desire vs. necessity

F.5,7. (*Based on individual mother*) If your work situation/home life/support/etc. were different, would you have used pumping differently? How so?

F.5,7. If you didn't have to pump, do you think you still would have? Why or why not?

F.3,11,12. What were some of the things that made feeding at the breast work for you? Was there anything that made it more challenging overall?

F.5,13,14. What were some of the things that made pumping work for you? Was there anything that made it more challenging overall?

F.7. If someone told you she was "breastfeeding," what would you think she meant?

F.3,5,6,7. If you have another baby, what have you taken away from this experience that you might use for next time? Or if you aren't planning on another baby, if you had a friend tell you she was pregnant and thinking about breastfeeding or pumping, what advice might you give her?

F. 8,19. If you did have another baby, what goals might you set out for yourself? How are these related to your experiences with your baby now? How confident would you feel about your ability to meet those goals?

## **F2. Final Interview: Mother is still feeding pumping or feeding HM at 1 year postpartum**

*(General opener)* We're talking today because it's been about a year since you had your baby, and over a year since I met you! So I'd like to talk about how things are going now, and your thoughts about the last year.

### *Feeding at the breast*

F.11. You told me that you've still been feeding your baby at the breast since I was here last. Has that only been when you're at home? Tell me about how that's been going.

F.11. Walk me through what happens when you feed your baby at the breast. *Further probes* for choosing sides, feeding from one or two and why, etc.

*Probe:* F.11. What has changed or stayed the same about breastfeeding since last time I was here?

*Probe:* F.3. What are your influences in breastfeeding at this point? Can you describe for me why it's important to you to be breastfeeding at this time?

*Probe:* F.3,19. How are you feeling about breastfeeding right now? Do you feel like it's something that is working for you? Tell me about why you feel that way.

*Probe:* F.2,8. What are your thoughts looking forward from now about breastfeeding? How do you see it fitting in to how you feed your baby?

*Probe:* F.2,8. Is there a time you see yourself no longer breastfeeding? Tell me about that.

### *Using a breast pump*

F.13. Are you using your breast pump at this point?

*(If yes)* How has that been working for you?

F.13,23. Have you been using your pump at work? Walk me through what happens when you pump your milk at work.

*Probe:* F.13,23. Has your pumping routine changed at all since last time I was here? Tell me about those changes. What brought them about?

F.13. Have you been pumping while you're at home? Tell me about how that happens.

*Probe:* F.4. What are your influences in using the pump at home as well as at work?

*Probe:* F.13. When do you use your pump at home? Why is this when you use your pump?

F.13,14. Is keeping track of your milk amount something that's important to you? Tell me about why you feel that way. What do you learn from keeping track of that?

F.13,14. What happens with your pumped milk?

F.13,14,20,21. Have you had any problems or difficulties with pumping? Was there anything you were confused about, or any questions that you had? If so, did you seek out help? Tell me about that.

F.5,19. How are you feeling about pumping right now? Do you feel like it's something that is working for you?

F.5,6,7,19. Do you feel like pumping is helping you meet the goals you have for yourself? How? How would you describe how formula fits in with breastfeeding for you?

*(If no)* F.13,23. Tell me about the time leading up to when you stopped using your pump.

*Probe:* F.13,14,23. How was pumping going for you around then? Do you feel like it was working for you? If not, what wasn't going the way you'd hoped?

*Probe:* F.13,23. Were you using your pump at work? Had that changed since last time I was here? Tell me about those changes.

*Probe:* F.13,23. Were you using your pump at home? Had that changed since last time I was here? Tell me about those changes.

*Probe:* F.13,14. Was keeping track of your milk amount something that's important to you? Tell me about why you felt that way. What did you learn from keeping track of that?

*Probe:* F.13,14. Were you working towards moving away from pumping in this time? If so, what were your influences in deciding it was time to stop pumping?

*Responsiveness and cues, attitudes about FAB vs EHM*

F.17. Since I was here last, how have you known it was time to feed the baby when you're with him/her?

*Probe, whether cue is infant-directed or time-directed:* F.20. How did you know to use this to decide when to feed the baby?

*Probe, whether cue is infant-directed or time-directed:* F.20. How did you know to use this to decide when to feed the baby? Is this the same or different from the last time I was here?

*Probe:* F.3,6,7,11,12,15,16. *(If mother was both feeding at the breast and bottle-feeding pumped milk or formula)* When your baby has mealtime, what influences whether it's at the breast or from a bottle?

*Probe:* F.20. When you are feeding your baby a bottle, how does a feeding usually end?

What about when you're breastfeeding your baby, how does a feeding usually end?

*Alternatively,* How can you tell that a feeding is over?

*Probe:* F.7,15,16. Is your baby getting any of your pumped milk at this point? Tell me how your pumped milk fits in with how you feed your baby.

*Probe:* F.6,7. (*If mother is feeding formula*) How would you describe how formula fits in with breastfeeding for you? What are some of your influences in using formula while you breastfeed? *Probe* for how his perception may align with or differ from the role of EHM

*Attitudes and perceptions, Confidence and HM sufficiency*

F.3,5,6,11-16,19. Looking back from before you had your baby to now, what were some of the things that you anticipated about feeding your baby that you ended up experiencing?

F.3,5,6,11-16,19. Was there anything about feeding your baby that wasn't what you anticipated?

F.3,11,12. How do you feel about your experiences feeding your baby at the breast?

F.5,6,13-16. How do you feel about your experiences using a pump? Feeding your pumped milk?

F.5,7. Looking back, how do you think pumping fit into breastfeeding for you? *Probes* for degree of involvement, desire vs. necessity

F.5,7. (*Based on individual mother*) If your work situation/home life/support/etc. were different, would you have used pumping differently? How so?

F.5,7. If you didn't have to pump, do you think you still would have? Why or why not?

F.3,11,12. What were some of the things that made feeding at the breast work for you? Was there anything that made it more challenging overall?



F.5,13,14. What were some of the things that made pumping work for you? Was there anything that made it more challenging overall?

F.7. If someone told you she was “breastfeeding,” what would you think she meant?

F.3,5,6,7. If you have another baby, what have you taken away from this experience that you might use for next time? Or if you aren’t planning on another baby, if you had a friend tell you she was pregnant and thinking about breastfeeding or pumping, what advice might you give her?

F. 8,19. If you did have another baby, what goals might you set out for yourself? How are these related to your experiences with your baby now? How confident would you feel about your ability to meet those goals?

*Closer:* Everybody’s experience is so different, and there are always things I don’t think to ask because I’m not in your shoes. Is there anything we haven’t talked about that you feel is important? Is there anything you think I should have asked that I didn’t?

## APPENDIX C

### CHARACTERISTICS OF IFPS II MOTHERS WHO WERE CONSIDERED FOR INCLUSION IN SURVIVAL ANALYSES

This appendix details a range of socio-demographic, lactation, delivery, pump, and pumping characteristics among four groups of mothers in the IFPS II (**Table 14**). We examined these characteristics as we narrowed our sample from all mothers who ever fed HM ( $n = 2,557$ ) to those who still fed HM 1.5 – 4.5 mo (1,696), those who fed and pumped HM 1.5-4.5 months ( $n = 1,116$ ) and those with HME frequency data 1.5-4.5 months ( $n = 1,044$ ). The women in this final column were assessed for completion on potential model covariates for eligibility in survival models (see Chapter 4).

## APPENDIX D

### COMPARISON OF MOTHERS' REPORTS OF PUMPING PRACTICES

This appendix details the comparison between different measures of pumping practices found in the Infant Feeding Practices II (IFPS II) surveys. Three IFPS II surveys, sent to mothers when infants were 2, 5, and 7 months old, included modules on mothers' pumping practices and experiences. Mothers reported how many times they pumped in the 2 weeks prior to returning surveys. They also answered a question about whether they were pumping on a “regular schedule” or not—hereafter called “occasional” pumpers—and reported when, if ever, they had begun pumping on a regular schedule. These three questions yielded a continuous variable, for number of pumping episodes in the previous two weeks (**Table 15**), and a categorical variable for regular *vs.* occasional pumping.

Because we intended to perform analyses examining both categorical and continuous pumping as predictors of long-term human milk-feeding outcomes, regular *vs.* occasional pumping was considered as a potential exposure. However, this delineation is inherently problematic, as both “regular” and “schedule” are subjective terms. Namely, some mothers may interpret these terms as a reflection of how much they pumped, in which case this variable should align with regular *vs.* occasional pumping. Yet, even still, mothers' perceptions of what constitutes a high or low amount of pumping may differ substantially. Moreover, other mothers may interpret “regular” and “schedule” to reflect consistency in pumping practices. For example, mothers who pump only a few times a week, but do so at the same times and on the same days each week, may have responded that they were pumping on a regular schedule.

Thus, an important question to answer for these analyses was how much reported pumping frequency and reported regular vs. occasional pumping reflect the same exposure. This question also has important implications for future national surveys. Namely, the degree of overlap in actual pumping practices between mothers who identify as pumping on a regular schedule must be understood to characterize the utility of this question in future surveys. In other words, although mothers self-identification as regular or occasional pumpers may be informative descriptively, it may not be informative for epidemiologic analyses.

As such, we converted pumping frequency data to a dichotomous variable to directly compare it to the dichotomous characterization of mothers as regular or occasional pumpers. We did this in two ways: by dividing pumping frequency on the mean and on the median. This mean and median were identified among women who both pumped and fed human milk between 1.5-4.5 months and had data on pumping frequency ( $n = 1,044$ ). In this group, the mean pumping frequency was 13.055 episodes in the previous 2 wk, or 0.9325 pumping episodes per day, and the median pumping frequency was 6 episodes in the previous 2 wk, or 0.42857 pumping episodes per day. This discrepancy suggests that a small proportion of mothers in this group pump with far greater frequency than the rest, driving the mean frequency upward. This further suggests that the median may be a more appropriate delineation for a categorical pumping frequency variable. Nevertheless, we conducted  $\chi^2$  analyses of the association between regular vs. occasional pumping and pumping frequency divided at both the mean (**Table 16**) and the median (**Table 17**).

When pumping frequency was characterized as below vs. at or above the mean, 83.54% of mothers divided along expected lines—i.e. mothers who pump below the mean frequency and identify as occasional pumpers, and mothers who pump at or above the mean frequency and

identify as regular pumpers. However, 16.45% of mothers were characterized in opposite directions. Of the 6.19% of mothers who pumped at or above the mean frequency yet identified themselves as occasional pumpers, the frequency of pumping ranged from 14—88 episodes in the previous 2 wk, or 1—6.285 episodes per day. The mean frequency in this group was 26.72 episodes over 2 weeks, or 1.909 episodes per day. The median frequency in this group was 20.00 episodes in the previous 2 weeks, or 1.429 episodes per day. Of the 10.26% of mothers who pumped below the mean frequency but identified as regular pumpers, the frequency of pumping ranged from 1—13 episodes in the previous 2 wk, or 0.071—0.929 episodes per day. The mean and median pumping frequency in this group were 8.17 and 10 pumping episodes over 2 weeks, or 0.584—0.714 episodes per day.

The takeaway message from this examination is that the dichotomous regular *vs.* occasional pumping variable does not separate mothers into mutually exclusive groups based on their actual pumping practices. This leads to two conclusions. First, as the exposure of interest in our analyses is the amount that mothers pump, not mothers' interpretations of that amount, we should instead examine mothers in two groups split based on their pumping frequency. Given the tailing issues in these frequency data—namely, a small group of mothers that pump much more than the rest—the median is a more appropriate split. Second, this tells us that asking mothers whether they see themselves to be pumping on a “regular schedule” or not does not have as much epidemiologic utility as direct questions about pumping frequency. Unless future investigators are interested in examining the impact of mothers' interpretations of their pumping practices on outcomes, this question should be revised so as to have more epidemiologic utility.

## APPENDIX E

### METHODS FOR CREATING VARIABLES FOR THE DURATION OF ANY AND EXCLUSIVE HUMAN MILK-FEEDING AND OF FEEDING AT THE BREAST

This appendix details the creation of duration variables that were used as outcomes in epidemiologic analyses, including the duration of feeding human milk (HM), the duration of feeding at the breast (FAB), the duration of exclusive HM-feeding, and the duration of absence of formula feeding (FF) or complementary foods (CF). These durations were calculated using data from the longitudinal survey cohort, the Infant Feeding Practices Study II (IFPS II). Data from each survey at months 1, 2, 3, 4, 5, 6, 7, 9, 10, and 12 months were used to assess feeding behaviors at each month. These monthly characterizations, in turn, were used to calculate duration variables of interest.

#### **Feeding types in each month**

The first step to creating duration variables was to characterize feeding behaviors at each month. This characterization was sometimes complicated by questions with unclear meanings, missing data from skipped questions, and conflicting answers. Thus, we employed questions that both directly and indirectly indicated behaviors and compared mothers' answers to these questions within surveys. Infants' foods were directly listed on the first question in Module A on each month's survey: "In the past 7 days, how often was your baby fed each food listed below? Include feedings by everyone who feeds the baby and include snacks and night-time feedings." Other indications of feeding behaviors came from other questions that indirectly referenced relevant behaviors, as described below.

*Feeding any human milk.* Mothers indicated the number of “breast milk” feedings infants received with the question described above. Some mothers only checked this line rather than giving a number. Reflecting methods by IFPS II authors and investigators (##), we considered this an affirmative indication of HM-feeding. Other questions examined in Module A included those asking about pumped human milk-feeding and those about whether infants fed from both breasts or let go of breasts during feedings. Any affirmative answer on these questions was taken as an indication of HM-feeding.

*Feeding at the breast.* The FAB status of each dyad was determined with two criteria. First, the number of human milk feeds reported on Module A on each survey was compared to the number of pumped human milk feeds reported in the same module. When the number of human milk feeds reported was substantially higher than the number of pumped human milk feeds reported, this suggested that some human milk-feeds were at the breast. Second, it was considered an affirmation of FAB if mothers indicated that infants fed from both breasts during feedings or let go of either or both breasts after feedings.

*Feeding infant formula.* Whether an infant was fed formula in a given month was ascertained by looking at responses to a number of direct questions about FF. Module A on each month included questions reporting the number of formula feeds as well as five indirect questions about the amount and type of formula infants consumed. In addition, Module E, which was included in survey months 2, 5, and 9, was examined for any affirmation of FF.

*Feeding solids and other milks.* The presence of CF and other milks was ascertained with direct reports of foods infants consumed in Module A on each month’s survey.

*Feeding only human milk.* Whether infants were exclusively fed human milk was inferred by looking at their statuses for FF, CF, and other milks on each month. In other words, if it had

been determined that an infant hadn't been fed formula nor solids in that month, that infant was considered exclusively HM-fed.

### **Calculation of censored durations by infant ages.**

Two types of duration variables were created. *Inclusion* variables measured the duration that a behavior was present. These included the presence of feeding any HM and any FAB. *Exclusion* variables measured the duration that a behavior was absent, including the absence of formula, solids, and other milks. A sample mother is shown in **Table 18** to illustrate these calculations. Inasmuch as mothers returned surveys with highly variable turnaround time, durations were calculated based on the infant's age at the time of survey return rather than the month of the survey.

*Inclusion variables.* To determine how long a behavior was present, we identified the last month in which the behavior was reported. The end of that behavior was assumed to have fallen between the last survey on which a behavior was reported and the next survey. For example, the fictional sample mother in **Table 18** last reported feeding HM on the month-9 survey. As such, the duration of HM-feeding was calculated as the midpoint between the infant's ages when the mother returned survey months 9 and 10. The duration of FAB was calculated as the midpoint between the infant's ages when the mother returned survey months 6 and 7.

*Exclusion variables.* To determine how long a behavior was absent, we identified the first month in which the behavior was reported. The start of that behavior was assumed to have fallen between the first survey on which a behavior was reported and the previous survey. For example, the mother in **Table 18** first reported FF on the month-3 survey. Although month 4 included no FF, it is the duration of complete exclusion of formula that is of interest. Thus, the duration of no



FF was calculated as the midpoint between the infant's ages when the mother returned survey months 2 and 3. As the first report of CF came in month 5, the duration of no CF was calculated as the midpoint of the infant's ages when the mother returned survey months 4 and 5. Taking FF and CF together, the infant was exclusively HM-fed on the surveys at months 1, 2, and 4. Thus, the duration of exclusive HM-feeding was calculated as the midpoint of the infant's ages when the mother returned survey months 2 and 3.

*Missing data.* Many mothers did not return all surveys. Thus, the necessary adjacent survey to calculate the duration of a feeding practice of interest was not always available. For example, when a month was flagged as the last reported instance of feeding HM, a mother may not have returned the survey. For example, the mother described above may not have returned surveys for months 4 and 7 (**Table 19**). In this example, calculating the duration of time that the infant was not fed formula is unaffected. Although it is unknown whether formula was fed in month 5, the duration of time that this infant wasn't fed formula will still be the midpoint of the infant's ages on months 2 and 3 surveys. However, the fact that survey month 7 was not returned means that the infant's age on when the mother returned that survey cannot be used to calculate duration of feeding at the breast. In this case, the next available survey was used to calculate the midpoint. For mothers who were missing relevant surveys, the gap between a flagged survey month and the next adjacent survey month ranged from 2 to 7 months. Detailed descriptions of how variables were calculated or censored are described below for the duration of feeding any human milk (**Table 20**), feeding exclusive human milk (**Table 21**), and feeding at the breast (**Table 22**).

## APPENDIX F

### CREATION OF VARIABLE FOR MOTHERS' PERCEPTION OF LOW HUMAN MILK SUPPLY

This appendix details the conceptualization and creation of a dichotomous variable representing whether or not a mother perceived her human milk supply to be low or insufficient to meet her infant's needs. A range of epidemiologic and ethnographic data, including qualitative data reported in Chapters 1-3, support the importance of mothers' perceptions of her milk supply to her intentions and practices for feeding human milk. Thus, we created a variable to represent perceived low milk supply in survival curves reported in Chapter 4. Because the Infant Feeding Practices Study II surveys did not explicitly ask mothers about their perceptions of their milk supply, this variable was created using two questions that indirectly elicited these perceptions.

Perceptions of low milk supply were elicited from two questions related to mothers' reasons for pumping and for bottle-feeding formula while infants were still being fed human milk. Specifically, one of 9 options mothers could choose from a closed list of reasons for pumping was "To increase my milk supply." If mothers indicated that they pumped for this reason, this was considered a perception of low human milk supply. In addition, two of 32 options mothers could choose from a closed list of reasons for supplementing their human-milk fed infants with formula included "Breast milk alone did not satisfy my baby" and "I didn't have enough milk." Mothers rated the importance of each of these 32 reasons on Likert scales from "Not at all important" to "Very important." Mothers who indicated that either of these two reasons for formula supplementation was "Somewhat important" or "Very important" were considered to have perceived low human milk supply.

Altogether, 33.14% of human milk-feeding mothers who also pumped between 1.5-4.5 mo indicated that they did so to increase their supply (**Table 1**). In the same interval, 14.3% of mothers supplemented their infants with formula because they felt their milk wasn't enough to satisfy their infant, and 14.6% did so because they felt they didn't have enough milk. Altogether, 41.5% of mothers who both fed and pumped human milk between 1.5-4.5 reported low perceived human milk supply on any one or more of these questions.

Mothers' reports of pumping to increase their milk supply or feeding formula because of perceived inadequate supply differed by a range of socio-demographic factors. Pumping to increase milk supply was more common among mothers who reported pumping their milk regularly vs. occasionally, those who intended to feed human milk for < 12 months vs.  $\geq 12$  months, those who reported that their infants usually or always emptied their bottles between 1.5-4.5 months compared to those who did not report typical bottle emptying, and mothers who pumped for elective reasons compared to those who did not pump for elective reasons.

Formula supplementation because of mothers' perceptions that their milk alone wasn't enough to satisfy infants was more common among mothers with any postpartum maternal or infant participation in The Special Supplemental Nutrition Program for Women, Infants, and Children, those who had previous experience feeding HM, those who had prenatal intentions to feed any human milk for  $\geq 12$  vs. <12 months or exclusive human milk  $\geq 5$  vs. < 5 months, those who were not comfortable feeding at the breast in public, and those with earlier onset of lactogenesis II. Formula supplementation because of mothers' perceptions that their milk alone wasn't enough to satisfy infants was also more common among mothers who pumped for lactation reasons compared to those who did not and those who pumped for elective reasons

compared to those who did not. Formula supplementation to satisfy infants was also significantly associated with mothers' marital statuses and delivery types.

Formula supplementation because mothers felt they didn't have enough HM was more common among mothers who pumped occasionally *vs.* regularly, mothers who pumped for lactation reasons compared to those who did not and those who pumped for elective reasons compared to those who did not, and those who did not report typical infant bottle-emptying 1.5-4.5 months. Formula supplementation because mothers felt they didn't have enough HM was also more common among mothers who did not work between 1.5-4.5 months, those who had previous experience feeding HM, and those who had prenatal intentions to feed any human milk for  $\geq 12$  *vs.*  $< 12$  months or exclusive human milk  $\geq 5$  *vs.*  $< 5$  months, those with earlier onset of lactogenesis II, and those who had an unmedicated, vaginal delivery. Formula supplementation because of this perception was also more common among mothers who reported higher satisfaction with their pumps, those.

Mothers' dichotomous perceptions of low human milk supply—yes or no—also differed by socio-demographic factors. Perceived low human milk supply was more common among mothers who pumped regularly *vs.* occasionally, those who pumped for dyadic reasons compared to those who did not and those who pumped for elective reasons compared to those who did not, and mothers who used electric pumps *vs.* battery-powered or manual pumps. Perceptions of low milk supply were also more common among mothers who did not have previous experience feeding HM, those who intended to feed HM  $< 12$  months *vs.* those who intended to feed HM  $\geq 12$  months, those who intended to feed exclusive HM  $< 5$  months *vs.* those who intended to feed HM  $\geq 5$  months, those who were not embarrassed to feed at the breast in public, and those that observed infants emptying bottles most or all of the time between 1.5-4.5 months. Perceived low

milk supply was also more common among mothers who had income > 350% the national poverty level by household size compared to those with lower incomes and those who had medicated or Cesarean deliveries compared to unmedicated, vaginal deliveries.

Among mothers who reported pumping to increase their milk supply, 21.43% also reported that the perception that their infants weren't satisfied with human milk alone was an important determinant of their choice to supplement with formula. Of the mothers who pumped to increase their milk supply, 22.29% also reported that perceptions that they didn't have enough milk were important to their decision to supplement with formula. Among mothers who did not report pumping to increase their milk supply, 11.19% reported supplementing with formula because they felt their infants weren't satisfied with human milk alone, and 11.05% did so because they felt they didn't have enough milk.

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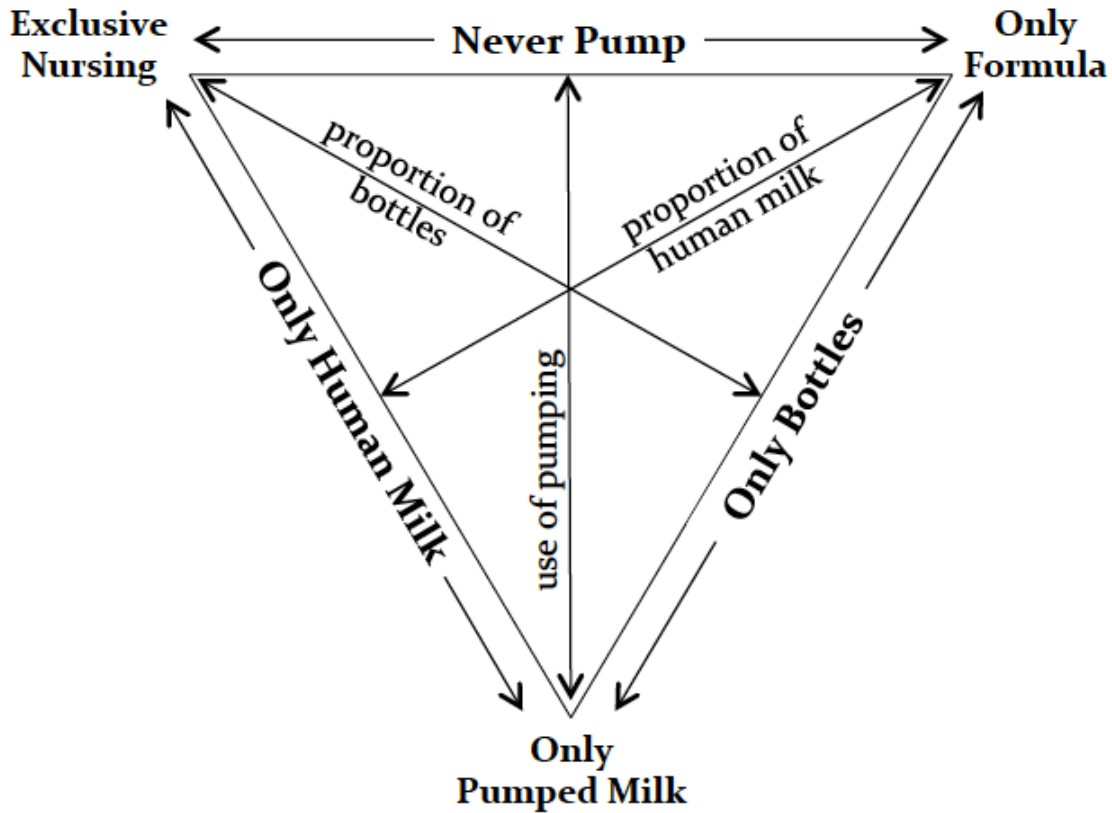
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## FIGURES

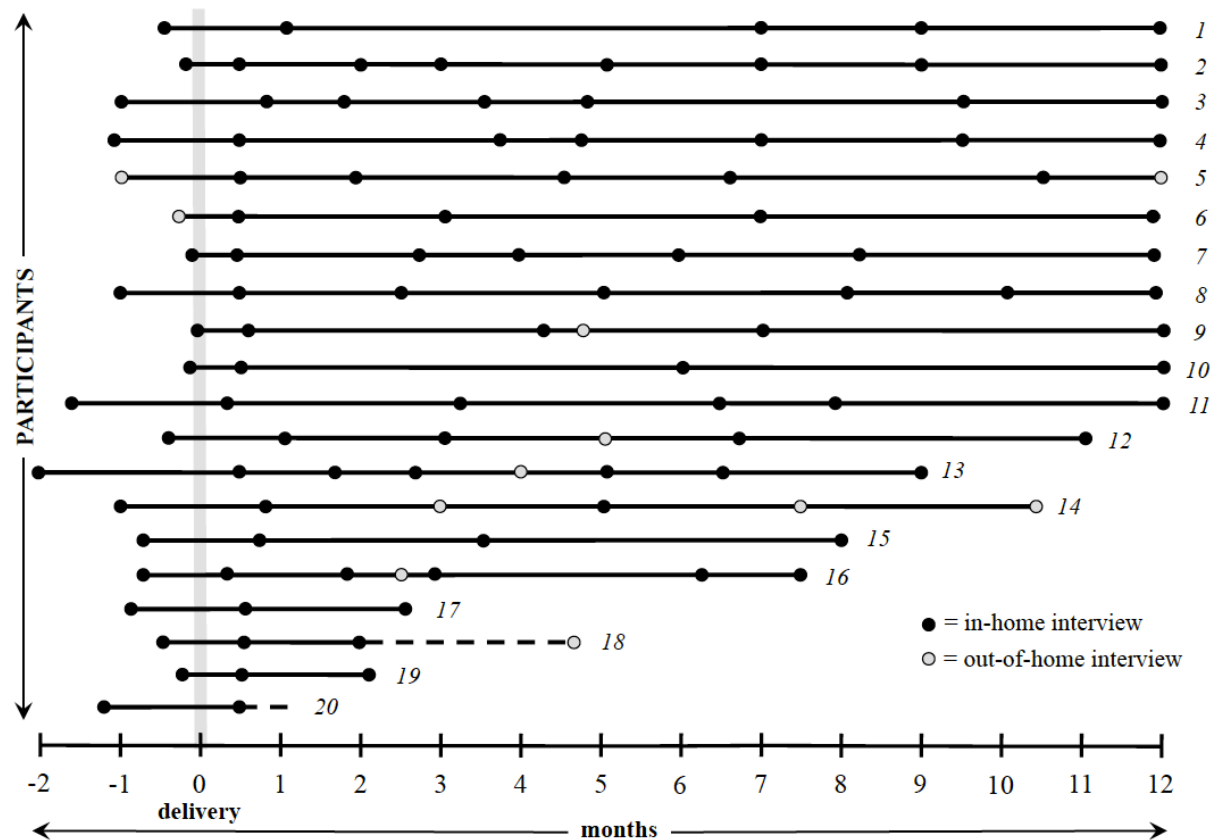
Figure 1. The new human milk-feeding landscape for mother and infant.



This figure shows how the nature of human milk-feeding have fundamentally changed with the incorporation of pumps and bottles. Until recently, the two extremes of infant feeding were exclusive nursing, or feeding directly at the breast, and exclusive bottle-feeding formula. Both mothers and infants could be characterized along the top edge of this triangle as either entirely nursing, entirely formula-feeding, or some combination of the two. Now, a new extreme has emerged: exclusively feeding pumped human milk to infants. With this change, we may now describe infants both by the proportion of their feeds that are human milk and by the proportion of their feeds that come from bottles, regardless of content. Mothers may now also be described

by how much they feed at the breast as well as how much they pump human milk from their breasts.

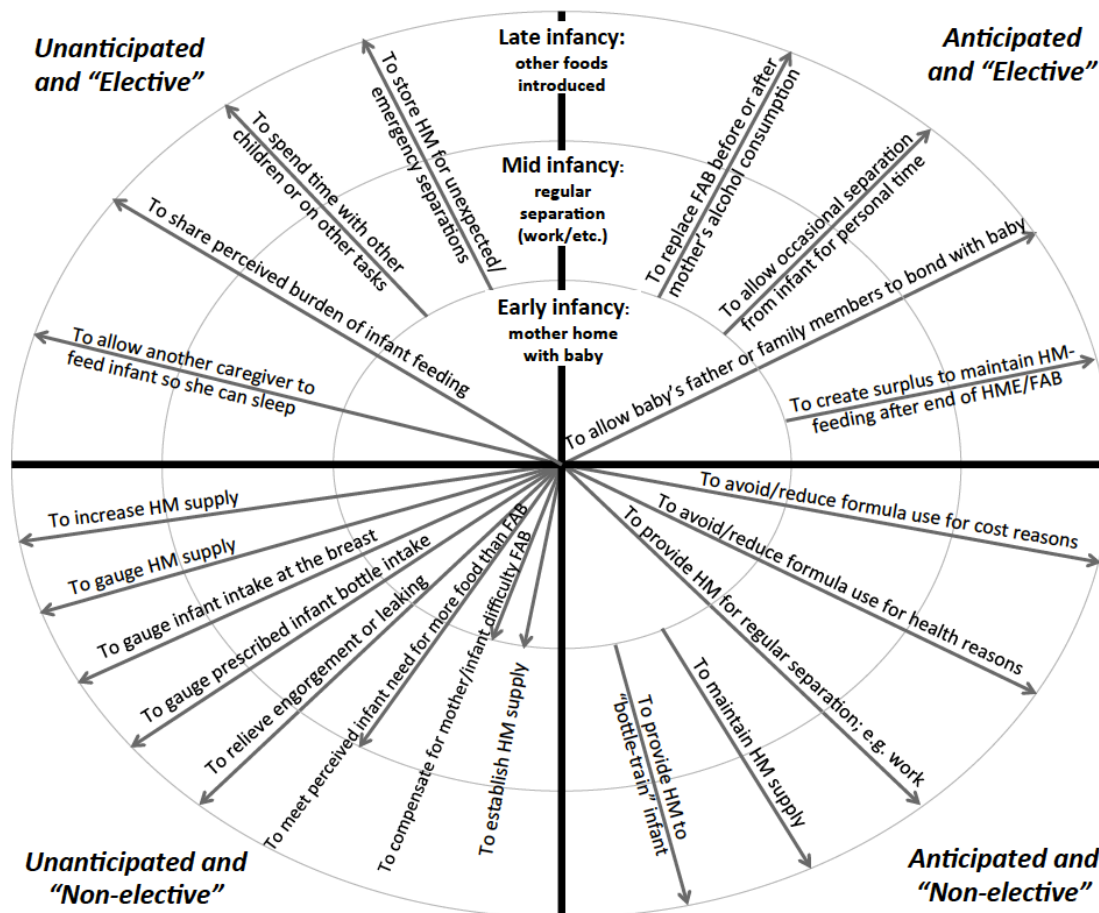
**Figure 2. Frequency and distribution of semistructured interviews with ethnography participants from pregnancy through up to 1 y postpartum**



This figure shows the duration of participation (in months) and the distribution and frequency of interviews for each participant. Each line represents a participant, numbered top to bottom by duration of reported HM-feeding for comparison with **Table 2**. Each circle represents a participant interview. Dotted lines indicate that participants left the study and initiated contact afterward—one to report a new pregnancy and discuss changed HME intentions and one to report a sudden move that necessitated study exit.



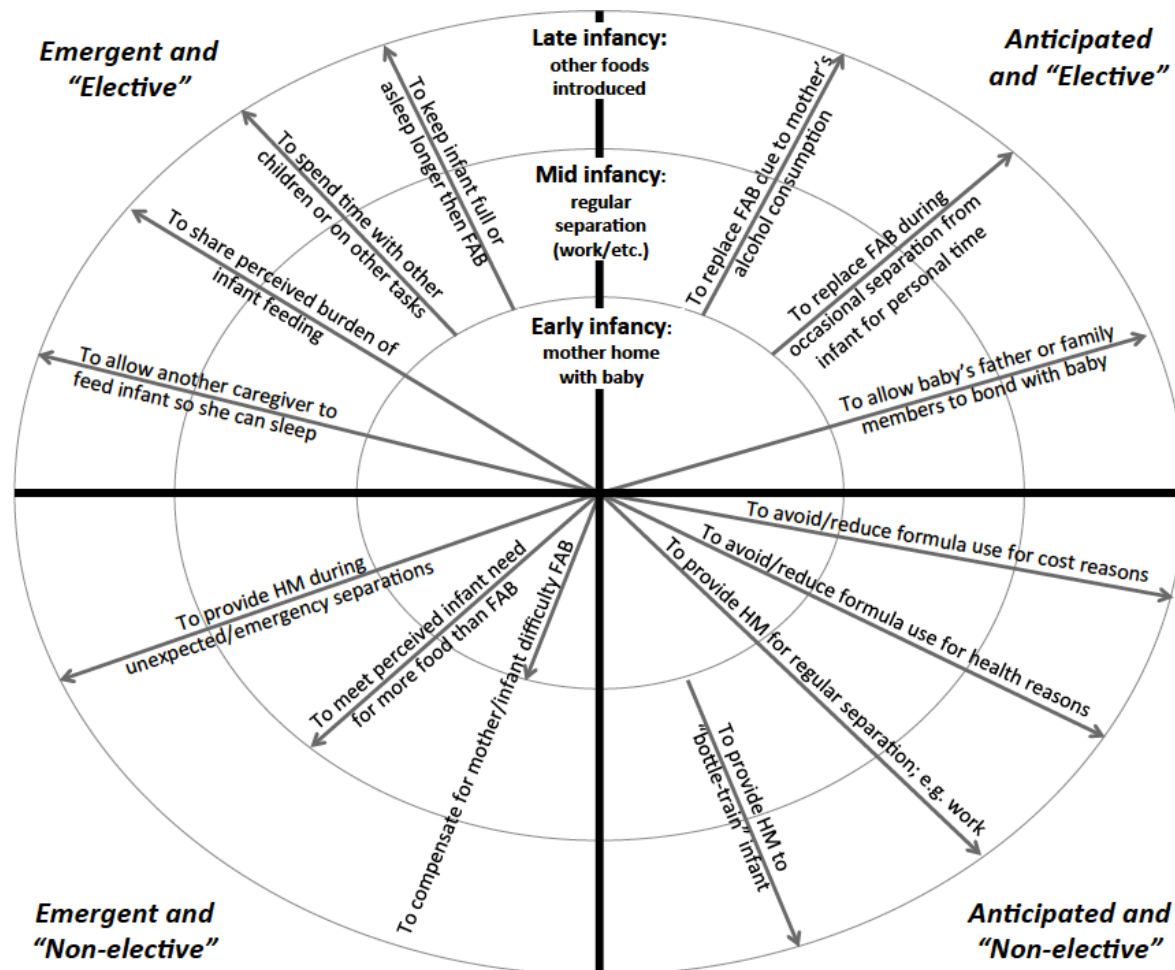
**Figure 3. Characterizing mothers' reasons for HME<sup>a</sup> in three descriptive intervals across the first year by whether they were anticipated or unanticipated and elective or non-elective.**



<sup>a</sup>Abbreviations used: HME, Human Milk Expression.

Mothers' reasons for HME were characterized by two factors: whether mothers anticipated HME for this reason or whether that reason for HME was unanticipated, and whether mothers' reasons for HME were elective or non-elective from mothers' perspectives. Circles represent three dyadic stages chosen descriptively as, they occurred at different times between dyads. The first stage may be described as when mother and infant are mainly together, the second as when more regular separation occurs, and the third as when solids are also fed.

**Figure 4. Characterizing mothers' reasons for bottle-feeding HM<sup>a</sup>, or having other caregivers do so, in three descriptive intervals across the first year by whether they were anticipated or emergent and elective or non-elective.**

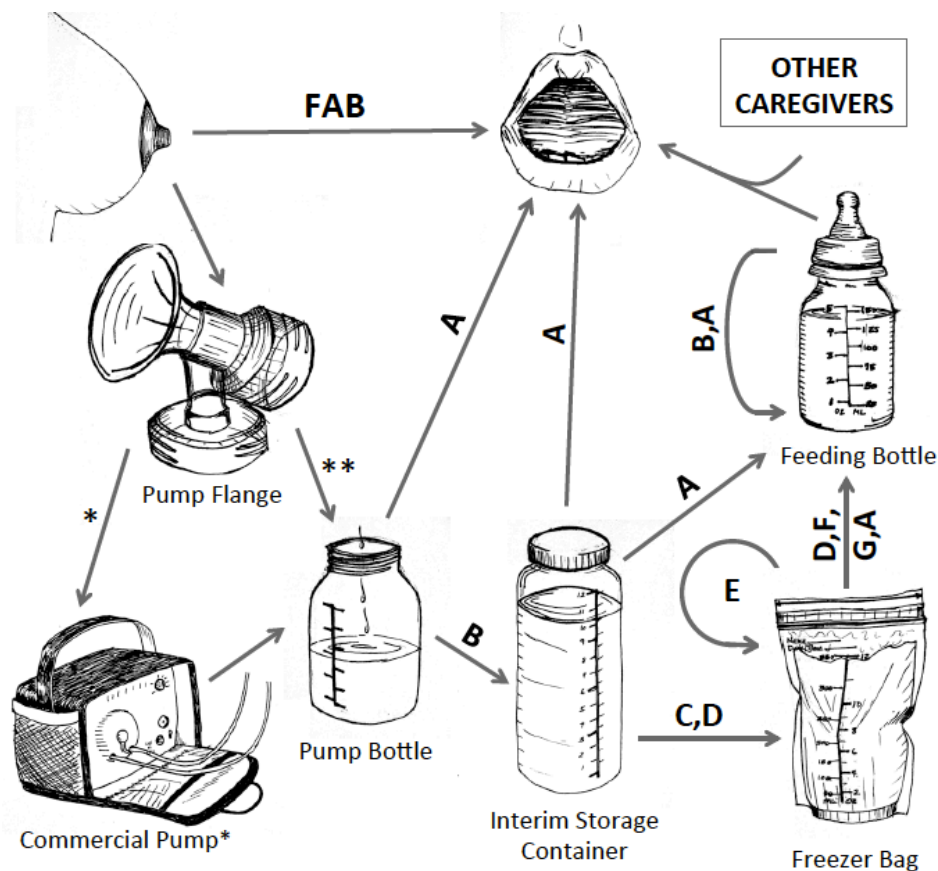


<sup>a</sup>Abbreviations used: HM, Human Milk.

Mothers' reasons for bottle-feeding pumped HM were characterized by two factors: whether mothers anticipated bottle-feeding for this reason or whether that reason for bottle-feeding was emergent, and whether mothers' reasons for bottle-feeding were elective or non-elective from mothers' perspectives. Circles represent three dyadic stages chosen descriptively as, they occurred at different times between dyads. The first stage may be described as when mother and

infant are mainly together, the second as when more regular separation occurs, and the third as when solids are also fed.

**Figure 5. Temperature and container changes to pumped HM<sup>a</sup> before feeding to infants**



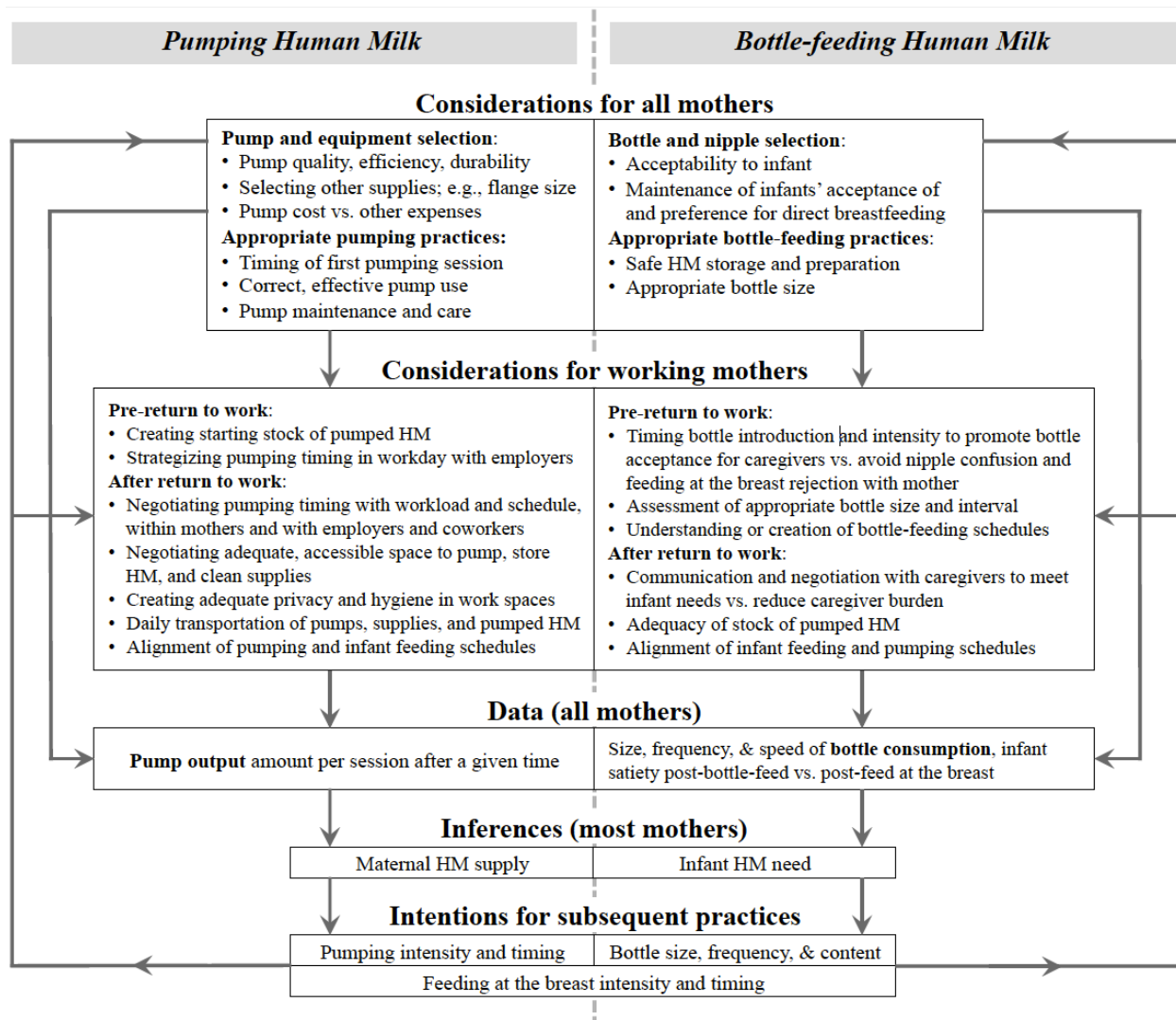
<sup>a</sup>Abbreviations used: HM, human milk; FAB, feeding at the breast.

\*Commercially-available pumps, designed for single users, have open systems.

\*\*Hospital-grade pumps have closed systems, and are safe for multiple users.

This figure shows potential containers in contact with and temperature treatments done to HM between HME session and feeding pumped HM to infant. Temperature changes include **A** = warming, **B** = refrigeration, **C** = transportation, **D** = freezing, **E** = temperature fluctuations from storage in freezer door, **F** = thawing at room temperature, **G** = thawing in refrigerator. Among mothers in this sample, all potential paths of HM between breast and infant were followed: i.e. some mothers fed HM directly from pump bottle, others used all container and temperature changes shown.

**Figure 6. Mothers' considerations and interpretations related to pumping and bottle-feeding HM<sup>a</sup> to their infants.**

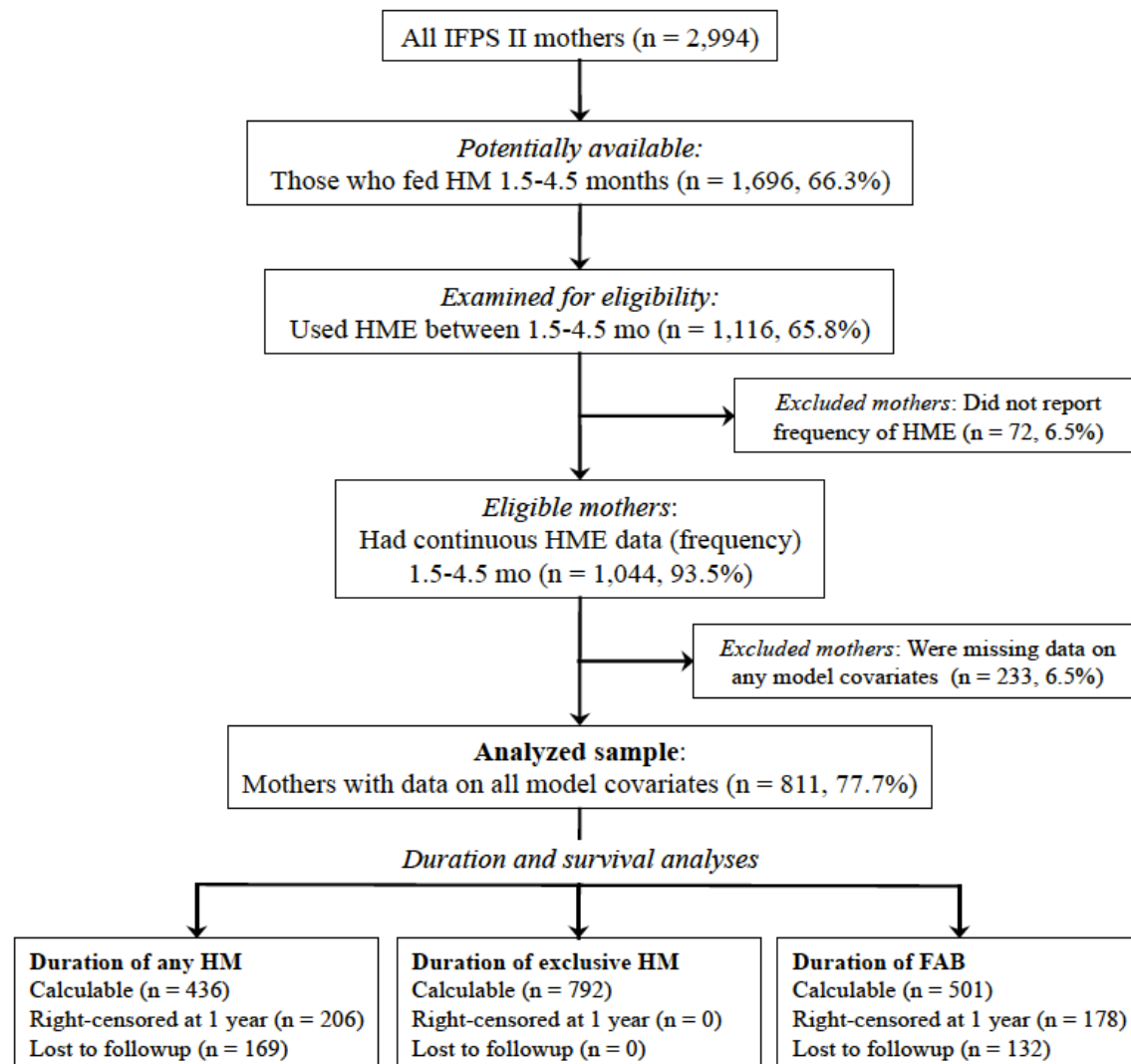


<sup>a</sup>Abbreviations used: HM, human milk.

This figure should be read from the top down, from practical considerations for pumping and bottle-feeding HM at the top to data collected and consequent inferences and intentions at the bottom. These intentions, manifested in subsequent practices, then lead to continued practical considerations. To reflect that pumps and bottles split feeding at the breast into two separately occurring phenomena, removing HM from mothers' breasts and feeding infants, this figure may

also be read in two sides. The left side of the figure shows mothers' considerations related to pumping, and the right side shows those related to bottle-feeding HM. Feeding at the breast is included under intentions as they were impacted by considerations and cognitive processes for pumping and bottle-feeding HM, and shown on both sides as it both removes HM from breasts and feeds it to infants.

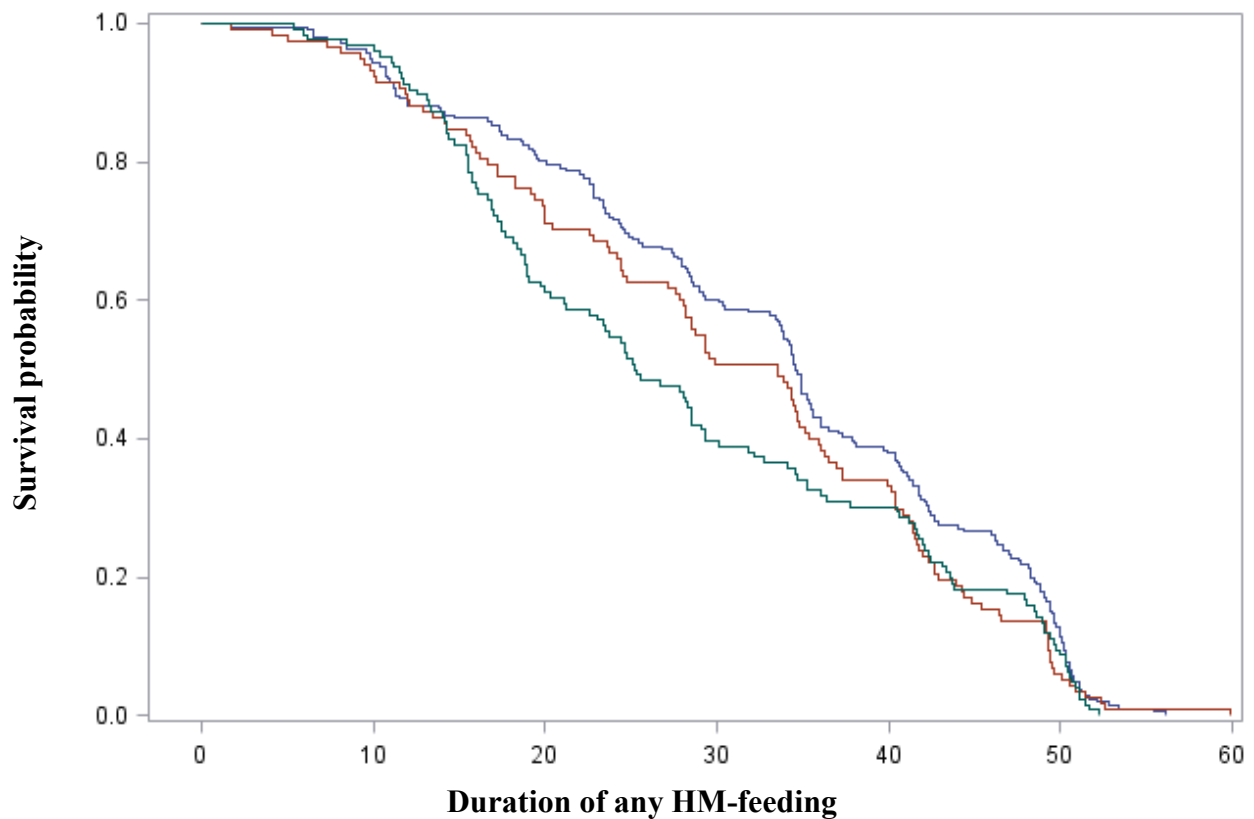
**Figure 7. Inclusion of IFPS II<sup>a</sup> mothers into samples for Aim 2 analyses.**



<sup>a</sup>Abbreviations used: IFPS II = Infant Feeding Practices Study II, HM = human milk, HME = HM expression, FAB = feeding at the breast.

This figure shows how mothers were identified for survival analyses of associations between HME practices and long-term feeding durations. The top of the figure shows all IFPS II mothers, further narrowed by their HM-feeding and HME practices between 1.5-4.5 mo. Mothers who both fed and pumped HM between 1.5-4.5 mo were further narrowed by whether they had data available for HME frequency in the previous 2 weeks for survival analyses.

**Figure 8. Survival curves showing the duration of any HM<sup>a</sup>-feeding among 811 mothers who pumped and fed HM at 1.5-4.5 months and had complete data on model covariates.**

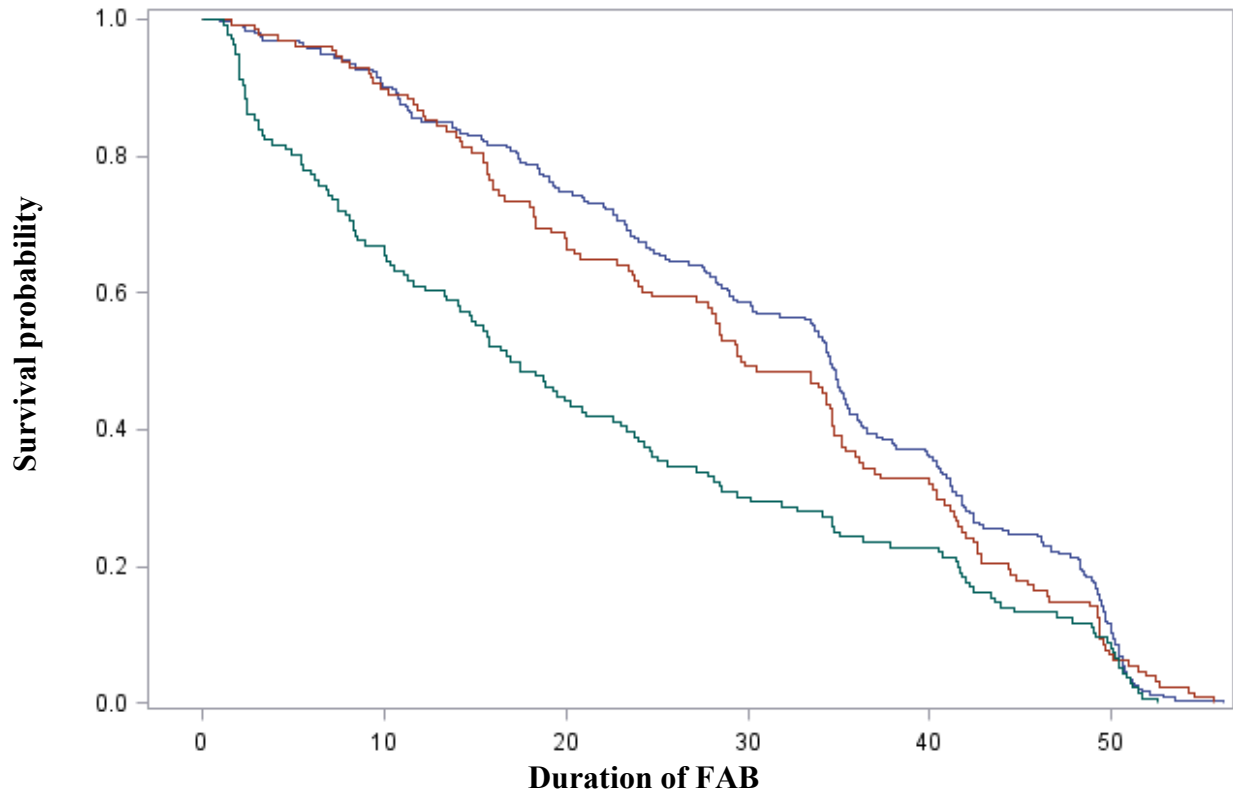


<sup>a</sup>Abbreviations used: HM, human milk.

This figure shows the survival of any HM feeding among three groups of mothers: those who pumped less or as frequently than the group mean (blue line), those who pumped at a frequency in the third quartile (red line), and those who pumped at a frequency in the highest quartile (green line).



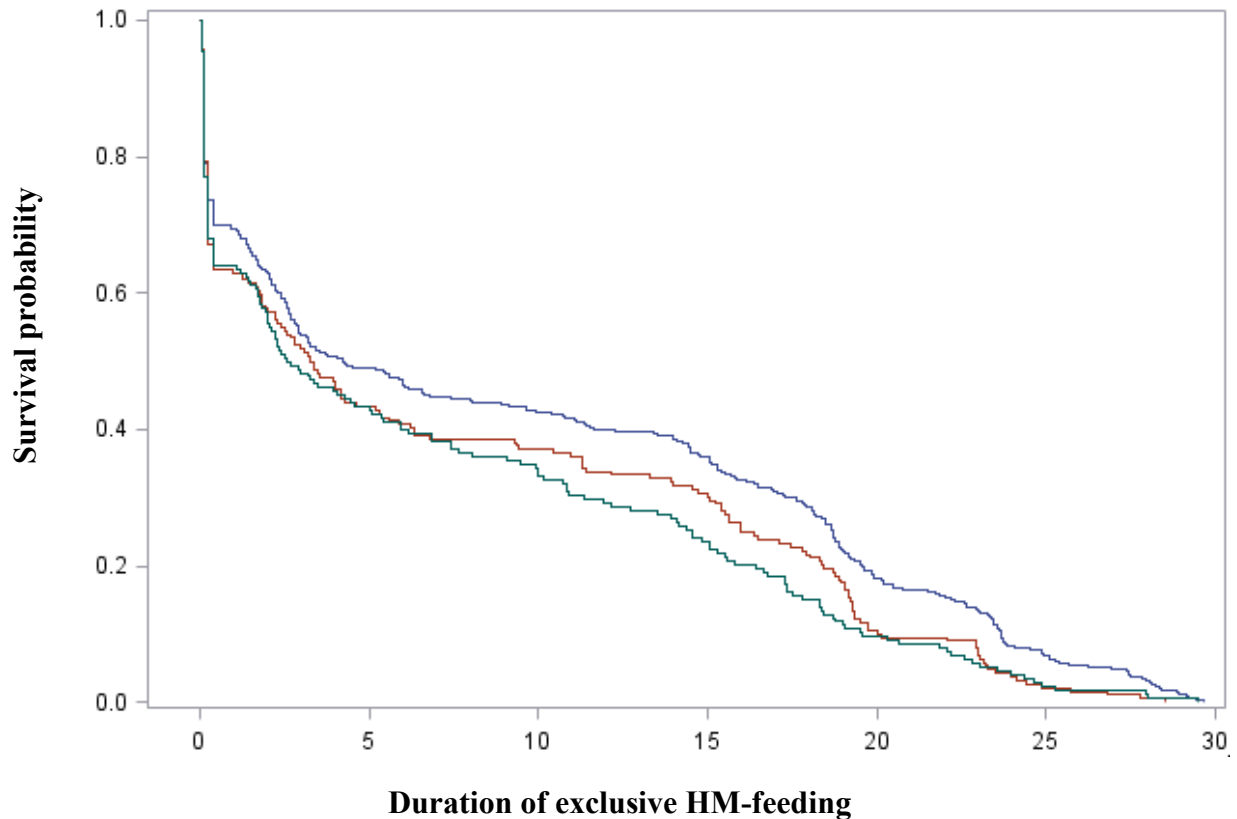
**Figure 9. Survival curves showing the duration of FAB<sup>a</sup> among 811 mothers who pumped and fed HM at 1.5-4.5 months and had complete data on model covariates.**



<sup>a</sup>Abbreviations used: HM, human milk; FAB, feeding at the breast.

This figure shows the survival of FAB among three groups of mothers: those who pumped less or as frequently than the group mean (blue line), those who pumped at a frequency in the third quartile (red line), and those who pumped at a frequency in the highest quartile (green line).

**Figure 10. Survival curves showing the duration of exclusive HM<sup>a</sup>-feeding among 811 mothers who pumped and fed HM 1.5-4.5 months and had complete data on model covariates.**



<sup>a</sup>Abbreviations used: HM, human milk.

This figure shows the survival of exclusive HM feeding among three groups of mothers: those who pumped less or as frequently than the group mean (blue line), those who pumped at a frequency in the third quartile (red line), and those who pumped at a frequency in the highest quartile (green line).

## TABLES

**Table 1. Socio-demographic characteristics of all ethnography participants.**

<b>Characteristic</b>	<b>Participants (n)<sup>a</sup></b>
Age (mean, sd)	29.8 (4.22)
Ethnicity	
White	12
Black	4
Hispanic	2
Asian	2
Marital status	
Married	14
Partnered, co-habiting	4
Single	2
Return to work	
None	5
≤ 3 mo	12
3 - 6 mo	3
Parity	
Primiparous	8
Multiparous	12
Prior FAB experience	
Yes	10
No	10
Prior HME experience	
Yes	8
No	12
Prior formula-feeding experience	
Yes	11
No	9
Prior bottle-feeding HM experience	
Yes	10
No	10
Education	
≤ high school	1
some college	6
college	8
> college	5

<sup>a</sup>Unless noted otherwise.

**Table 2. The type, number, and prior use of human milk expression methods and pumps used by ethnography participants**

PARTICIPANT	Method of expression												
	Double electric				<i>Type of pump</i> Single electric				Manual				Hand Expression
	Hospital grade												
	New	Rented	Used, known	Used, stranger	New	Rented	Used, known	Used, stranger	New	Rented	Used, known	Used, stranger	
1		♦					♦		♦				♦
2			♦										
3	♦												
4	♦												
5	♦												
6	♦												
7									♦				♦
8	♦♦												♦
9	♦		♦										
10	♦												♦
11									♦				♦
12					♦				♦				♦
13					♦				♦				
14	♦	♦♦											
15		♦							♦				
16					♦								
17					♦								
18		♦											
19				♦									
20				♦					♦				

Participant mothers, labeled 1-20 as in **Figure 2**, used many methods for HME. Some mothers used more than one type of pump over time, or two of the same type. Six mothers used hand expression at some point.

**Table 3. Classification of HME<sup>a</sup> reasons as elective vs. non-elective.**

<b>Reason for Pumping</b>	<b>Classification</b>
To relieve engorgement	Non-elective
Because my nipples were too sore to nurse	Non-elective
To increase my milk supply	Non-elective
To get milk for someone else to feed my baby	Ambiguous <sup>b</sup>
For me to feed to my baby when I do not want to breastfeed or when baby cannot breastfeed	Non-elective
To keep my milk supply up when my baby could not nurse (such as while you were away from your baby or when your baby was too sick to nurse)	Non-elective
To mix with cereal or other food	Elective
To have an emergency supply of milk	Elective
To donate to a baby other than my own	Elective

<sup>a</sup>Abbreviations used: HME, Human Milk Expression; FAB, feeding at the breast.

<sup>b</sup>Mothers most commonly reported using HME to get milk for another caregiver to feed.

However, our ethnographic work showed that most pumped HM is fed by other caregivers, for reasons that were both chosen by the mother and necessitated by circumstance. Thus, this reason could neither be defended as primarily *elective* or *non-elective*, and it was not used in the non-elective HME reasons score.

**Table 4. Outcomes for feeding any HM<sup>a</sup> associated with non-elective reasons for HME**

Number of non-elective reasons for HME	<i>N</i> <sup>b</sup>	Duration of feeding HM							
		n <sup>c</sup>	median (weeks)	≥ 6 mo		≥ 9 mo		≥ 12 mo	
				n <sup>c</sup>	% <sup>d</sup>	n <sup>c</sup>	% <sup>d</sup>	n <sup>c</sup>	% <sup>d</sup>
0	179	148	50.68	140	94.6	108	73.0	68	45.9
1	328	261	41.93	228	87.4	162	62.1	78	29.9
2	189	156	38.50	131	84.0	87	55.8	45	28.8
3-5	115	96	35.96	68	70.8	50	52.1	23	24.0
Total participants	811	661	41.93	567	85.8	407	61.6	214	32.4

<sup>a</sup>Abbreviations used: HM, human milk; HME, HM expression.

<sup>b</sup>The mothers included in this table include those with data on HME frequency and all model covariates. Thus, the numbers in this column represent the number of women drawn from this larger group (n = 811) who have each non-elective pumping reasons score.

<sup>c</sup>The numbers in this column represent the number of mothers available to calculate median duration. This number includes mothers for whom a feeding duration could be calculated as well as those who were right-censored at study end. To include mothers who were right-censored at study end for still feeding HM at 12 months, this group was given an arbitrary duration of 15 months, a duration chosen to reflect feeding HM beyond 12 months and any reported value from other IFPS II mothers.

<sup>d</sup>The percentages in these columns represent the proportion of mothers still feeding HM at 6, 9, and 12 months out of the number included in the median duration calculations. Mothers who were right-censored at study end were considered to have been feeding HM at each time point.

**Table 5. Outcomes for FAB<sup>a</sup> associated with non-elective reasons for HME**

Number of non-elective reasons for HME	<i>N</i> <sup>b</sup>	Duration of feeding at the breast							
		n <sup>c</sup>	median (weeks)	≥ 6 mo		≥ 9 mo		≥ 12 mo	
				n <sup>c</sup>	% <sup>d</sup>	n <sup>c</sup>	% <sup>d</sup>	n <sup>c</sup>	% <sup>d</sup>
0	179	150	49.96	135	90.0	102	68.0	64	42.7
1	328	268	37.86	210	78.4	150	56.0	65	24.3
2	189	163	34.72	123	75.5	80	49.1	39	23.9
3-5	115	95	27.22	57	60.0	41	43.2	19	20.0
Total participants	811	676	38.93	525	77.7	373	55.2	187	27.7

<sup>a</sup>Abbreviations used: HM, human milk; HME, HM expression; FAB, feeding at the breast.

<sup>b</sup>The mothers included in this table include those with data on HME frequency and all model covariates. Thus, the numbers in this column represent the number of women drawn from this larger group (n = 811) who have each non-elective pumping reasons score.

<sup>c</sup>The numbers in this column represent the number of mothers available to calculate median duration. This number includes mothers for whom a feeding duration could be calculated as well as those who were right-censored at study end. To include mothers who were right-censored at study end for still FAB at 12 months, this group was given an arbitrary duration of 15 months, a duration chosen to reflect FAB beyond 12 months and any reported value from other IFPS II mothers.

<sup>d</sup>The percentages in these columns represent the proportion of mothers still FAB at 6, 9, and 12 months out of the number included in the median duration calculations. Mothers who were right-censored at study end were considered to have been FAB at each timepoint.

**Table 6. Outcomes for exclusive HM<sup>a</sup>-feeding associated with non-elective reasons for HME**

Number of non-elective reasons for HME	<i>N</i> <sup>b</sup>	Duration of feeding exclusive HM							
		n <sup>c</sup>	median (weeks)	≥ 2 mo		≥ 4 mo		≥ 6 mo	
				n <sup>c</sup>	% <sup>d</sup>	n <sup>c</sup>	% <sup>d</sup>	n <sup>c</sup>	% <sup>d</sup>
0	179	173	11.43	98	56.6	57	32.9	10	5.8
1	328	312	3.86	128	41.0	82	26.3	12	3.8
2	189	184	2.36	68	37.0	46	25.0	3	1.6
3-5	115	95	1.93	26	27.4	15	15.8	4	4.2
Total participants	811	784	3.39	320	40.8	200	25.5	29	3.7

<sup>a</sup>Abbreviations used: HM, human milk; HME, HM expression.

<sup>b</sup>The mothers included in this table include those with data on HME frequency and all model covariates. Thus, the numbers in this column represent the number of women drawn from this larger group (n = 811) who have each non-elective pumping reasons score.

<sup>c</sup>The numbers in this column represent the number of mothers available to calculate median duration. This number includes all mothers for whom a feeding duration could be calculated.

<sup>d</sup>The percentages in these columns represent the proportion of mothers still feeding exclusive HM at 2, 4, and 6 months out of the number included in the median duration calculations.



**Table 7. The number of non-elective reasons for HME<sup>a</sup> and hazard of stopping HM-feeding**

<b>Comparison group</b>	<b>Adjustment</b>	<b>HR (95% CI)</b>
1 non-elective HME reason vs. 0		
Feeding any HM	Adjusted <sup>b</sup>	1.42 (1.08 - 1.69)
FAB	Adjusted <sup>c</sup>	1.40 (1.08 - 1.81)
Feeding exclusive HM	Adjusted <sup>d</sup>	1.21 (1.00 - 1.47)
2 non-elective HME reasons vs. 0		
Feeding any HM	Adjusted <sup>b</sup>	1.31 (0.97 - 1.75)
FAB	Adjusted <sup>c</sup>	1.36 (1.03 - 1.80)
Feeding exclusive HM	Adjusted <sup>d</sup>	1.35 (1.09 - 1.67)
3-5 non-elective HME reasons vs. 0		
Feeding any HM	Adjusted <sup>b</sup>	1.63 (1.18- 2.26)
FAB	Adjusted <sup>c</sup>	1.79 (1.31 - 2.45)
Feeding exclusive HM	Adjusted <sup>d</sup>	1.76 (1.38 - 2.23)

<sup>a</sup>Abbreviations used: HM, human milk; HME, HM expression; FAB, feeding at the breast; HR, hazard ratio.

<sup>b</sup>Full models were adjusted for mothers' age, marital status (married, widowed, divorced, separated, or never married) and level of education achieved (high school or less, some college, or  $\geq$  college), and their level of satisfaction with their most-used pump (high vs. low to medium).

<sup>c</sup>Full models were adjusted for mothers' age, level of education achieved (high school or less, some college, or  $\geq$  college), their level of satisfaction with their most-used pump (high vs. low to medium), and whether their most used pump was used or new when they obtained it.

<sup>d</sup>Full models were adjusted for mothers' level of satisfaction with their most-used pump (high vs. low to medium), whether mothers' most-used pumps were new or used, mothers race/ethnicity (white, black, Asian/Pacific Islander, Hispanic, or other), BMI category (normal weight, overweight, or obese), hours worked per week upon return to work (0, 1-19, 20-34, or  $\geq$  35 hours per week), and timing of first HME episode.



<sup>a</sup>Abbreviations used: HM, human milk; HME, HM expression; Q1, Quartile 1; Q2, Quartile 2; Q3, Quartile 3; Q4, Quartile 4;

<sup>b</sup>The numbers in this column represent the number of mothers available to calculate median duration. This number includes mothers for whom a feeding duration could be calculated as well as those who were right-censored at study end. To include mothers who were right-censored at study end for still feeding HM at 12 months, this group was given an arbitrary duration of 15 months, a duration chosen to reflect feeding HM beyond 12 months and any reported value from other IFPS II mothers.

<sup>c</sup>The percentages in these columns represent the proportion of mothers still feeding HM at 6, 9, and 12 months out of the number included in the median duration calculations. Mothers who were right-censored at study end were considered to have been feeding HM at each timepoint.

This table shows the median duration of feeding HM among groups of women separated by the frequency with which they reported pumping their HM in the previous 2 weeks between 1.5-4.5 months. HME frequency was separated in two ways: first, at the median, and second, into mutually-exclusive quartiles. This table also shows the proportion of mothers in each group who are still feeding HM at 6, 9, and 12 months.

**Table 9. Duration of FAB by HME frequency category.**

Pumping Frequency Group	N (mothers in group)	Duration of FAB					
		n	median (weeks)	≥ 6 mo (26 weeks)		≥ 9 mo (39 weeks)	
				n	%	n	%
Mothers who feed HM but <b>do not pump</b> between 1.5-4.5 months	493	395	49.1	318	80.5	249	63.0
Mothers who feed HM and pump <b>at all</b> between 1.5-4.5 months and have frequency data	1,044	866	37.0	649	74.9	467	53.9
Mothers who feed HM and pump <b>at all</b> between 1.5-4.5 months and have frequency data and all model covariates	811	676	38.9	525	77.7	373	55.2
Mothers who feed HM and pump < <b>median frequency</b> between 1.5-4.5 months and have all model covariates	436	358	46.215	321	89.7	233	65.1
Mothers who feed HM and pump ≥ <b>median frequency</b> between 1.5-4.5 months	375	313	29.683	204	65.2	140	44.7
Mothers who feed HM and pump <b>@ frequency in Q1 (1-3 times/2 weeks)</b> between 1.5-4.5 months and have all model covariates	283	222	46.7	206	92.8	145	65.3
Mothers who feed HM and pump <b>@ frequency in Q2 (4-6 times/2 weeks)</b> between 1.5-4.5 months and have all model covariates	153	136	46.0	115	84.6	88	64.7
Mothers who feed HM and pump <b>@ frequency in Q3 (7-14 times/2 weeks)</b> between 1.5-4.5 months and have all model covariates	194	158	35.2	123	77.8	82	51.9
Mothers who feed HM and pump <b>@ frequency in Q4 (15-115 times/2 weeks)</b> between 1.5-4.5 months and have all model covariates	181	160	22.8	81	50.6	58	36.3

<sup>a</sup> Abbreviations used: HM, human milk; HME, HM expression; FAB, feeding at the breast; Q1, Quartile 1; Q2, Quartile 2; Q3, Quartile 3; Q4, Quartile 4;

<sup>b</sup>The numbers in this column represent the number of mothers available to calculate median duration. This number includes mothers for whom a feeding duration could be calculated as well as those who were right-censored at study end. To include mothers who were right-censored at study end for still feeding HM at 12 months, this group was given an arbitrary duration of 15 months, a duration chosen to reflect feeding HM beyond 12 months and any reported value from other IFPS II mothers.

<sup>c</sup>The percentages in these columns represent the proportion of mothers still feeding HM at 6, 9, and 12 months out of the number included in the median duration calculations. Mothers who were right-censored at study end were considered to have been feeding HM at each timepoint.

This table shows the median duration of FAB among groups of women separated by the frequency with which they reported pumping their HM in the previous 2 weeks between 1.5-4.5 months. HME frequency was separated in two ways: first, at the median, and second, into mutually-exclusive quartiles. This table also shows the proportion of mothers in each group who are still FAB at 6, 9, and 12 months.



<sup>a</sup>Abbreviations used: HM, human milk; HME, HM expression; Q1, Quartile 1; Q2, Quartile 2; Q3, Quartile 3; Q4, Quartile 4;

<sup>b</sup>The numbers in this column represent the number of mothers available to calculate median duration. This number includes mothers for whom a feeding duration could be calculated as well as those who were right-censored at study end. To include mothers who were right-censored at study end for still feeding HM at 12 months, this group was given an arbitrary duration of 15 months, a duration chosen to reflect feeding HM beyond 12 months and any reported value from other IFPS II mothers.

<sup>c</sup>The percentages in these columns represent the proportion of mothers still feeding HM at 6, 9, and 12 months out of the number included in the median duration calculations. Mothers who were right-censored at study end were considered to have been feeding HM at each timepoint.

This table shows the median duration of feeding exclusive HM among groups of women separated by the frequency with which they reported pumping their HM in the previous 2 weeks between 1.5-4.5 months. HME frequency was separated in two ways: first, at the median, and second, into mutually-exclusive quartiles. This table also shows the proportion of mothers in each group who are still feeding HM at 6, 9, and 12 months.

**Table 11. Associations between HME<sup>a</sup> practices 1.5-4.5 mo and duration of any HM-feeding among 811 mothers who fed HM and used HME 1.5-4.5 mo.**

Predictor	Adjustment	HR (95% CI)	<i>p</i>
Categorical exposure model:			
HME frequency Q3 vs. < median	Unadjusted <sup>b</sup>	1.177 (0.939 - 1.477)	0.158
HME frequency Q4 vs. < median	Unadjusted <sup>b</sup>	1.290 (1.033 - 1.609)	0.024
HME frequency Q3 vs. < median	Adjusted <sup>b</sup>	1.326 (1.044 - 1.865)	0.021
HME frequency Q4 vs. < median	Adjusted <sup>b</sup>	1.401 (1.095 - 1.793)	0.007
Continuous exposure model:			
Frequency of HME in prior 2 wk <sup>c</sup>	Unadjusted	1.054 (1.006 - 1.104)	0.026
Frequency of HME in prior 2 wk	Adjusted <sup>d</sup>	1.062 (1.013 - 1.112)	0.012

<sup>a</sup>Abbreviations used: HME, Human Milk Expression; HM, Human Milk; HR, Hazard Ratio; CI, Confidence Interval

<sup>b</sup>Full models were adjusted for mothers' age, marital status (married, widowed, divorced, separated, or never married) and level of education achieved (high school or less, some college, or ≥ college), whether they worked at all between 1.5-4.5 months, and their level of satisfaction with their most-used pump (high vs. low to medium).

<sup>c</sup>HRs are presented for an increase of 10 HME episodes in the previous 2 wk. This number was chosen to reflect one additional HME episode per workday for two full work weeks.

<sup>d</sup>Full models were adjusted for mothers' age, marital status (married, widowed, divorced, separated, or never married), level of education achieved (high school or less, some college, or ≥ college), and their level of satisfaction with their most-used pump (high vs. low to medium).



**Table 12. Associations between HME<sup>a</sup> practices 1.5-4.5 mo and duration of FAB among 811 mothers who fed HM and used HME 1.5-4.5 mo.**

Predictor	Adjustment	HR (95% CI)	<i>p</i>
Categorical exposure model:			
HME frequency Q3 vs. < median	Unadjusted	1.077 (0.867 - 1.338)	0.503
HME frequency Q4 vs. < median	Unadjusted	1.566 (1.266 - 1.936)	<0.0001
HME frequency Q3 vs. < median			<0.0001
At median FAB duration (38.93 weeks postpartum)	Adjusted <sup>b</sup>	1.137 <sup>c</sup> (0.870 - 1.486)	
At 3 months postpartum	Adjusted <sup>b</sup>	30.310 (19.372 - 49.404)	
At 6 months postpartum	Adjusted <sup>b</sup>	5.904 (4.331 - 8.047)	
At 9 months postpartum	Adjusted <sup>b</sup>	1.127 (0.862 - 1.473)	
HME frequency Q3 vs. < median			<0.0001
At median FAB duration (38.93 weeks postpartum)	Adjusted <sup>b,c</sup>	0.990 (0.706 - 1.388)	
At 3 months postpartum	Adjusted <sup>b,c</sup>	41.872 (26.925 - 65.115)	
At 6 months postpartum	Adjusted <sup>b,c</sup>	6.406 (4.640 - 8.844)	
At 9 months postpartum	Adjusted <sup>b,c</sup>	0.980 (0.699 - 1.374)	
Continuous exposure model:			
Frequency of HME in prior 2 weeks <sup>d</sup>	Unadjusted	1.201 (1.142 - 1.262)	<0.0001
Frequency of HME in prior 2 weeks <sup>d</sup>			<0.0001
With low HM supply perception	Adjusted <sup>e,f</sup>	1.129 (1.059 - 1.204)	
Without low HM supply perception	Adjusted <sup>e,f</sup>	1.342 (1.224 - 1.472)	

<sup>a</sup>Abbreviations used: HM, Human Milk; HME, HM expression; HR, Hazard Ratio; CI, Confidence Interval.

<sup>b</sup>Full models were adjusted for mothers' age, level of education achieved (high school or less, some college, or  $\geq$  college), whether they worked at all between 1.5-4.5 months, their level of satisfaction with their most-used pump (high vs. low to medium), whether their most used pump was used or new when they obtained it, and whether mothers reported indicators that they perceived their HM supply to be low.

<sup>c</sup>A significant time-dependent effect was also found in this model, such that HRs between comparison groups differed significantly across the year. Thus, HRs are presented for four

distinct time points: at the time at which 50% of mothers were still FAB to any degree (38.93 weeks postpartum) and at 3, 6, and 9 months postpartum.

<sup>d</sup>HRs are presented for an increase of 10 HME episodes in the previous 2 wk. This number was chosen to reflect one additional HME episode per workday for two full work weeks.

<sup>e</sup>Full models were adjusted for whether mothers worked at all between 1.5-4.5 months, their level of satisfaction with their most-used pump (high vs. low to medium), level of education achieved (high school or less, some college, or  $\geq$  college), and whether they reported indicators of perceived low HM supply.

<sup>f</sup>This model also included a significant time-dependent effect of mothers' continuous HME frequency on duration of FAB. However, the inclusion or exclusion of a covariate representing this time-dependent effect did not substantially impact either the main effect parameter or its statistical significance. Thus, it was excluded from the model for simplicity.

**Table 13. Associations between HME<sup>a</sup> practices 1.5-4.5 mo and duration of exclusive HM-feeding among 811 mothers who fed HM and used HME 1.5-4.5 mo.**

Predictor	Adjustment	HR (95% CI)	<i>p</i>
Categorical exposure model:			
HME frequency Q3 vs. < median	Unadjusted <sup>b</sup>	1.245 (1.047 - 1.481)	0.013
HME frequency Q4 vs. < median	Unadjusted <sup>b</sup>	1.324 (1.110 - 1.581)	0.002
HME frequency Q3 vs. < median <sup>a</sup>	Adjusted <sup>b</sup>	1.201 (1.002 - 1.439)	0.048
HME frequency Q4 vs. < median <sup>a</sup>	Adjusted <sup>b</sup>	1.279 (1.047 - 1.562)	0.016
Continuous exposure model:			
Frequency of HME in prior 2 wk <sup>c</sup>	Unadjusted <sup>b</sup>	1.102 (1.058 - 1.147)	< 0.0001
Frequency of HME in prior 2 wk	Adjusted <sup>d</sup>	1.084 (1.038 - 1.133)	0.0003

<sup>a</sup>Abbreviations used: HM, Human Milk; HME, HM expression; HR, Hazard Ratio; CI, Confidence Interval; BMI, Body Mass Index.

<sup>b</sup>Full models were adjusted for mothers race/ethnicity (white, black, Asian/Pacific Islander, Hispanic, or other), BMI category (normal weight, overweight, or obese), hours worked per week upon return to work (0, 1-19, 20-34, or  $\geq 35$  hours per week), timing of first HME episode, whether mothers' most-used pumps were new or used, and mothers' level of satisfaction with their most-used pump (high vs. low to medium).

<sup>c</sup>HRs are presented for an increase of 10 HME episodes in the previous 2 wk. This number was chosen to reflect one additional HME episode per workday for two full work weeks.

<sup>d</sup>Full models were adjusted for mothers race/ethnicity (white, black, Asian/Pacific Islander, Hispanic, or other), BMI category (normal weight, overweight, or obese), hours worked per week upon return to work (0, 1-19, 20-34, or  $\geq 35$  hours per week), timing of first HME episode, whether mothers' most-used pumps were new or used, and mothers' level of satisfaction with their most-used pump (high vs. low to medium).

**Table 14. Socio-demographic, lactational, and pumping-related characteristics of mothers in the IFPS II<sup>a</sup> who ever fed HM and those who fed HM and pumped between 1.5-4.5 months postpartum**

<sup>a</sup>Abbreviations used: IFPS II, Infant Feeding Practices Study II; HM, Human Milk; HME, HM expression; BMI, Body Mass Index; PIR, Poverty Income Ratio.

<sup>b</sup>Not all mothers reported all of the characteristics described in this table. Thus, percentages in these columns reflect proportions among mothers who did return data on that characteristic.

<b>Characteristics and potential model covariates</b>	All mothers who ever fed HM ( <i>N</i> = 2,557) <sup>b</sup> (%)	All mothers who fed HM 1.5-4.5 months ( <i>N</i> = 1,696) <sup>b</sup> (%)	All mothers who fed HM and pumped 1.5-4.5 months ( <i>N</i> = 1,116) <sup>b</sup> (%)	All mothers with HME frequency data 1.5-4.5 months ( <i>N</i> = 1,044) <sup>b</sup> (%)
<i>Socio-demographic characteristics</i>				
race/ethnicity				
white	83.49	85.43	85.41	86.84
black	4.78	3.73	3.10	2.83
Hispanic	6.63	5.78	6.47	5.46
Asian/Pacific Islander	3.01	3.43	3.10	3.22
other	2.09	1.63	1.91	1.66
age				
mean (sd)	28.80 (5.45)	29.59 (5.12)	29.56 (5.13)	29.62 (5.08)
marital status				
married	80.25	85.74	85.62	86.37
widowed	0.29	0.12	0.19	0.20
divorced	2.77	2.47	2.44	2.30
separated	1.01	0.68	0.75	0.60
never married	15.68	10.99	11.00	10.52
region				
Northeast	36.37	35.79	36.02	35.60
Midwest	9.89	11.56	8.78	8.52
South	32.30	33.31	34.59	35.31
West	21.43	19.34	20.61	20.57
BMI				
normal	50.49	52.06	50.81	51.39
overweight	26.48	26.00	26.61	26.22
obese+	23.03	21.93	22.58	22.39
income				
<185% PIR	40.28	36.14	31.45	30.24
185-350% PIR	36.33	38.21	38.44	38.76
>350% PIR	23.39	25.65	30.11	31.00
WIC participation				
Yes	38.13	31.25	28.23	26.70
No	61.87	68.75	71.77	73.30
education				
High school or less	18.50	13.73	12.11	11.30
Some college	40.62	37.85	35.87	35.50
College+	40.88	48.42	52.02	53.20
any work 1.5-4.5 months				
Yes	44.92	44.64	51.34	52.44
No	55.08	55.36	48.66	47.56

return to work timing mean (sd)	12.89 (10.56)	12.87 (10.58)	12.43 (9.77)	12.43
return to work intensity				
0 hours/week	61.99	62.31	55.58	54.38
1-19 hours/week	12.69	14.94	15.56	16.08
20-34 hours/week	8.65	8.27	10.03	9.85
≥ 35 hours/week	16.17	14.48	18.83	19.69

*Lactation- and delivery-related variables*

HM-feeding experience				
Yes	64.16	70.44	64.34	64.29
No	35.84	29.56	35.66	35.71
intended HM-feeding duration				
< 12 mo	55.44	45.83	50.67	49.44
≥ 12 mo	44.56	54.17	49.33	50.56
intended exclusive HM-feeding duration				
< 5 mo	40.43	36.04	35.89	35.41
≥ 5 mo	59.57	63.96	64.11	64.59
embarrassment FAB in public				
No	61.95	57.43	61.47	61.34
Yes	38.05	42.57	38.53	38.66
lactogenesis II onset				
≤ 3 days	76.33	78.49	75.27	75.60
> 3 days	23.67	21.51	24.73	24.40
bottle-emptying 1.5-4.5 mo				
most of the time or always	56.79	53.54	63.80	63.64
never to sometimes	43.21	46.46	36.20	36.36
delivery type				
vaginal, unmed	15.55	18.34	15.18	15.26
vaginal, med	57.23	55.86	57.41	56.91
cesarean	27.22	25.80	27.40	27.83
gestational age at birth				
35-37 wk	4.61	3.48	4.12	4.02
≥ 37 wk	95.39	96.52	95.88	95.98

*Pumps and pumping practices*

pump type				
Electric or combination electric/battery-powered	N/A <sup>c</sup>	N/A	68.14	69.01
Battery-powered/manual	N/A	N/A	31.86	30.99

age of most-used pump at purchase				
new	N/A	N/A	73.85	73.43
used	N/A	N/A	26.15	26.57
satisfaction with most used pump				
High	N/A	N/A	82.02	83.45
Low	N/A	N/A	17.98	16.55
timing first HME episode				
mean (sd)	N/A	N/A	2.07 (2.24)	2.07 (2.24)
HME practices 1.5-4.5 mo				
< mean frequency	N/A	N/A	68.10	68.10
≥ mean frequency	N/A	N/A	31.90	31.90
< median frequency	N/A	N/A	47.51	47.51
≥ median frequency	N/A	N/A	52.49	52.49
HME for lactational reasons				
Yes	N/A	N/A	59.50	62.11
No	N/A	N/A	40.50	37.89
HME for dyadic reasons				
Yes	N/A	N/A	79.12	83.44
No	N/A	N/A	20.88	16.56
HME for elective reasons				
Yes	N/A	N/A	41.13	43.54
No	N/A	N/A	58.87	56.46

**Table 15. Statistics on reported HME<sup>a</sup> frequency among IFPS II mothers who pumped and fed HM between 1.5-4.5 months**

Statistic	Mothers with HME frequency data 1.5-4.5 months (n = 1,044)		Mothers with HME frequency data 1.5-4.5 months and complete data on model covariates (n = 811)	
	in previous 2 weeks	per day	in previous 2 weeks	per day
mean	12.337	1.762	13.067	1.867
s.d.	16.900	2.414	17.740	2.534
mode	1	0.143	1	0.143
100 % max	115	16.429	115	16.429
75% Q3	14	2.000	14	2.000
50% median	6	0.857	6	0.857
25% Q1	3	0.429	3	0.429
0% min	1	0.143	1	0.143

<sup>a</sup>Abbreviations used: HME, human milk expression; IFPS II, Infant Feeding Practices Study II; Q3, quartile 3, or 75<sup>th</sup> percentile; Q1, quartile 1, or 25<sup>th</sup> percentile.



**Table 16. Comparison of regular vs. occasional pumping and pumping frequency divided by the mean frequency among mothers who pump between 1.5-4.5 months**

		<b>Self-identification as pumping on “regular schedule” or not</b>	
		<i>occasional</i>	<i>regular</i>
<b>HME frequency</b>	$< \text{mean}$	638 (58.96%)	111 (10.26%)
	$\geq \text{mean}$	67 (6.19%)	266 (24.58%)

This table shows the comparison between mothers’ reports that they pumped regularly vs. not regularly (i.e., occasionally) and their reported frequency of pumping divided at the mean.

**Table 17. Comparison of regular vs. occasional pumping and pumping frequency, divided by the median frequency among mothers who pump between 1.5-4.5 months**

		<b>Self-identification as pumping on “regular schedule” or not</b>	
		<i>occasional</i>	<i>regular</i>
<b>HME frequency</b>	<i>&lt; median</i>	456 (44.27%)	28 (2.72%)
	<i>≥ median</i>	200 (19.42%)	346 (33.59%)

This table shows the comparison between mothers’ reports that they pumped regularly vs. not regularly (i.e., occasionally) and their reported frequency of pumping divided at the median.

**Table 18. Example of an IFPS IIa mother who has been categorized on each survey for practices for feeding any or exclusive HM, FAB, formula, and solids**

<b>Month</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>9</b>	<b>10</b>	<b>12</b>
<i>HM</i>	✓	✓	✓	✓	✓	✓	✓	✓	×	×
<i>FAB</i>	✓	✓	✓	✓	✓	✓	×	×	×	×
<i>FF</i>	×	×	✓	×	✓	✓	✓	✓	✓	✓
<i>CF</i>	×	×	×	×	✓	✓	✓	✓	✓	✓
<i>exHM</i>	✓	✓	×	✓	×	×	×	×	×	×

<sup>a</sup>Abbreviations used: IFPS II, Infant Feeding Practices Study II; HM, human milk; FAB, feeding at the breast; exHM, exclusive HM.

**Table 19. Example of an IFPS II<sup>a</sup> mother who has been categorized on feeding practices on all surveys except unreturned survey months 4 and 7**

<b>Month</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>9</b>	<b>10</b>	<b>12</b>
<i>HM</i>	✓	✓	✓	?	✓	✓	?	✓	×	×
<i>FAB</i>	✓	✓	✓	?	✓	✓	?	×	×	×
<i>FF</i>	×	×	✓	?	✓	✓	?	✓	✓	✓
<i>CF</i>	×	×	×	?	✓	✓	?	✓	✓	✓
<i>exHM</i>	✓	✓	×	?	×	×	?	×	×	×

<sup>a</sup>Abbreviations used: IFPS II, Infant Feeding Practices Study II; HM, human milk; FAB, feeding at the breast; exHM, exclusive HM.

**Table 20. Calculation and censoring of the duration of feeding any HM<sup>a</sup>**

<b>Last survey when FHM was reported</b>	<b>Next returned survey month</b>	<b>Duration variable status</b>	<b>n</b>
1	N/A	Calculated: accurate	11
1	2	Calculated: accurate	41
2	3	Calculated: accurate	55
2	4	Calculated: estimate, 2 month gap	8
2	5	Calculated: estimate, 3 month gap	4
2	6	Calculated: estimate, 4 month gap	1
2	7	Calculated: estimate, 5 month gap	1
2	9	Calculated: estimate, 7 month gap	1
2	none	Right-censored (lost to followup)	36
3	4	Calculated: accurate	47
3	5	Calculated: estimate, 2 month gap	6
3	6	Calculated: estimate, 3 month gap	3
3	7	Calculated: estimate, 4 month gap	1
3	9	Calculated: estimate, 6 month gap	1
3	none	Right-censored (lost to followup)	29
4	5	Calculated: accurate	46
4	6	Calculated: estimate, 2 month gap	4
4	7	Calculated: estimate, 3 month gap	1
4	9	Calculated: estimate, 5 month gap	2
4	10	Calculated: estimate, 6 month gap	2
4	12	Calculated: estimate, 6 month gap	3
4	none	Right-censored (lost to followup)	22
5	6	Calculated: accurate	56
5	7	Calculated: estimate, 2 month gap	5
5	9	Calculated: estimate, 4 month gap	1
5	10	Calculated: estimate, 5 month gap	2
5	none	Right-censored (lost to followup)	21
6	7	Calculated: accurate	55
6	9	Calculated: estimate, 3 month gap	4
6	10	Calculated: estimate, 4 month gap	1
6	12	Calculated: estimate, 6 month gap	4
6	none	Right-censored (lost to followup)	20
7	9	Calculated: accurate	68
7	10	Calculated: estimate, 3 month gap	5
7	12	Calculated: estimate, 5 month gap	6
7	none	Right-censored (lost to followup)	16
9	10	Calculated: accurate	68
9	none	Right-censored (lost to followup)	47
10	12	Calculated: accurate	118
10	none	Right-censored (lost to followup)	40
12	N/A	Right-censored (study end)	254

<sup>a</sup>Abbreviations used: HM, human milk; FHM, feeding human milk.

**Table 21. Calculation and censoring of the duration of exclusively feeding HM<sup>a</sup>**

<b>First month in which FF or CF reported</b>	<b>Closest previous survey returned</b>	<b>Duration variable status</b>	<b>n</b>
Hospital	N/A	Calculated: accurate	51
Hospital	N/A	Calculated: accurate	186
Hospital	N/A	Calculated: accurate	88
Hospital	N/A	Calculated: accurate	40
1	N/A	Calculated: accurate	227
2	1	Calculated: accurate	75
3	2	Calculated: accurate	43
4	3	Calculated: accurate	88
4	2	Calculated: estimate, 2 month gap	11
5	4	Calculated: accurate	118
5	3	Calculated: estimate, 2 month gap	13
5	2	Calculated: estimate, 3 month gap	5
6	5	Calculated: accurate	83
6	4	Calculated: estimate, 2 month gap	4
6	3	Calculated: estimate, 3 month gap	1
7	6	Calculated: accurate	29
7	5	Calculated: estimate, 2 month gap	3
7	3	Calculated: estimate, 4 month gap	3
9	7	Calculated: accurate	7
9	3	Calculated: estimate, 6 month gap	2
12	10	Calculated: accurate	1
12	4	Calculated: estimate, 6 month gap	1

<sup>a</sup>Abbreviations used: HM, human milk; FF, formula feeding; CF, complimentary foods.

**Table 22. Calculation and censoring of the duration of feeding at the breast**

<b>Last survey month in which FAB<sup>a</sup> was reported</b>	<b>Next returned survey month</b>	<b>Duration variable status</b>	<b>n</b>
1	N/A	Calculated: accurate	71
1	2	Calculated: accurate	65
2	3	Calculated: accurate	50
2	4	Calculated: estimate, 2 month gap	10
2	5	Calculated: estimate, 2 month gap	2
3	4	Calculated: accurate	30
3	4	Calculated: accurate	47
3	5	Calculated: estimate, 2 month gap	3
3	none	Right-censored: lost to follow-up	34
4	5	Calculated: accurate	43
4	6	Calculated: estimate, 2 month gap	4
4	7	Calculated: estimate, 3 month gap	1
4	9	Calculated: estimate, 5 month gap	4
4	1	Calculated: estimate, 6 month gap	1
4	none	Right-censored: lost to follow-up	20
5	6	Calculated: accurate	50
5	7	Calculated: estimate, 2 month gap	3
5	9	Calculated: estimate, 4 month gap	2
5	10	Calculated: estimate, 5 month gap	2
5	none	Right-censored: lost to follow-up	20
6	7	Calculated: accurate	48
6	9	Calculated: estimate, 3 month gap	4
6	10	Calculated: estimate, 4 month gap	1
6	12	Calculated: estimate, 6 month gap	3
6	none	Right-censored: lost to follow-up	17
7	9	Calculated: accurate	71
7	10	Calculated: estimate, 3 month gap	5
7	12	Calculated: estimate, 5 month gap	5
7	none	Right-censored: lost to follow-up	14
9	10	Calculated: accurate	67
9	12	Calculated: estimate, 3 month gap	13
9	none	Right-censored: lost to follow-up	26
10	12	Calculated: accurate	119
10	none	Right-censored: lost to follow-up	36
12	N/A	Right-censored: end of study	223
missing	N/A	N/A	2

<sup>a</sup>Abbreviations used: FAB, feeding at the breast.